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Evaluation of Alternative Crop Rotational Schemes for Cotton Production in Louisiana

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EVALUATION OF ALTERNATIVE CROP ROTATIONAL SCHEMES FOR COTTON PRODUCTION IN LOUISIANA

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ABSTRACT

Increasing economic importance of cotton production in Louisiana, awareness of the financial and environmental benefits of crop rotations have stressed the need for evaluating cotton production in different rotational schemes. The objective of this study was to estimate profitability of alternative crop rotational schemes within a whole farm context.

Yield data for 11 alternative production systems involving cotton, soybean, corn, wheat were obtained from the ongoing crop rotation research at the Northeast Research Station during the period 1983-1993. The systems included continuous, 2 year, and 3 year rotations on two soil types: silt and clay. Price data were generated given the distributions of adjusted seasonal average prices obtained from the department. Enterprise budgets were constructed for each crop, considering cotton as a program crop. A deficiency payment was included in the cotton income stream when the price fell below the target price. These budgets were used to calculate the net returns for each system. This resulted in 11 net return distributions consisting of 36 observations each. The net returns for the schemes containing cotton were generated both with and without deficiency payments. The net return distributions were then

analyzed in two Target MOTAD frameworks: a portfolio of all schemes and a portfolio of only continuous schemes both with and without deficiency payments.

Results suggest that a decision maker achieved higher expected income with continuous cotton as the major enterprise when deficiency payments were included. Without deficiency payments, the decision maker included continuous cotton in the optimal portfolio when only continuous schemes were available. The solution patterns for clay soil were identical except for the portfolio of all schemes with deficiency payment. All optimal portfolios were stable at the zero risk level.

CHAPTER 1
INTRODUCTION AND BACKGROUND

World cotton production, consumption, and trade have increased steadily since the 1950's. Current indications point to a continuation of these upward trends in the 1990's. World cotton trade is expected to expand during the next decade, although such expansion may be modest in comparison to consumption growth. According to projections by Barlowe, foreign mill use should continue to grow, approaching 100 million bales by the year 2000. Much of the production growth will likely occur in the major cotton producing countries. Globally, China and the U.S. rank first and second in cotton production, respectively. Cotton has long been the second most important source of farm income from crops in Louisiana. Louisiana is one of the major cotton producing states in the U.S., ranking fourth in the nation in terms of acreage of upland cotton planted and fifth in terms of bales produced in the period 1980-1992 (Agricultural Statistics).

Louisiana's share of cotton production has been stable at 6 percent of total U.S. upland cotton production (Agricultural Statistics). While Louisiana is endowed with adequate rainfall, many other cotton producing states are heavily dependent on irrigation. However, economic and legal constraints associated with irrigation have resulted in lower acreage planted in some states. In 1980, the acreage planted (in thousands) in California, Arizona and New Mexico were 1550, 550, and 151, respectively. In 1994, the plantings dropped to 1100, 313, and 55 thousand acres, respectively. The leading cotton producing state, Texas, also faced a water availability problem and experienced a huge decline in plantings from 7,850,000 acres in 1980 to 5,450,000 acres in 1994. These trends suggest possible future increases in cotton production in Louisiana and other states in the cotton belt.

While cotton is a major crop in Louisiana, other enterprises must be included in farm planning in order to maximize profit from a given set of resources. Farm managers typically consider the "whole farm" in allocating limited resources, not just a single enterprise. It is important to consider the relationships among enterprises. Some new enterprises may compete with existing enterprises, while others may actually increase the production of existing enterprises. Enterprises that compete for resources are those that require the same resources at the same time. An increased use of resources in one enterprise would require a reduction in another. Supplementary enterprises are those that require the same resources but at different times of the year. Enterprises are considered complementary if one enterprise contributes directly to another. For example, crop rotations involving cotton and a legume like soybean can result in reduction of the amount of fertilizer needed for satisfactory cotton yields.

Crop rotations typically involve a definite sequence of crops. There are two possible ways of implementing a sequential crop rotation. One approach involves planting the entire farm in a single crop each year. In this case, the same crop will only be grown again when its turn in the sequence arrives. This approach is not commonly practiced, particularly when special machines or equipment are required for specific crops, or when livestock are involved in the rotation. Sequential rotation is generally considered to be a more risky approach because the farmer is entirely dependent on the yield and price of a single crop each year. The second approach is to divide the farm into roughly equal parts, and rotate the crops within each part in a way that allows the total acreage of each crop grown on the farm to remain approximately constant each year. This is the practice followed by most farmers who adopt a rotation scheme.

Crop rotations have been practiced for hundreds of years around the world. Modern crop rotations were established as early as 1730 in England and have continued in some form into the 1990's. Funchess categorized the benefits of rotating crops in the South into three major areas: 1) maintenance of crop yields; 2) control of diseases, insects, and weeds; and 3) prevention of soil erosion. Before the extensive use of chemical fertilizers, maintenance or improvement of crop yields was best achieved by improving the base fertility of the soil. This usually required growing a legume crop to promote nitrogen fixation or applying manure to provide additional organic nutrients. In many cases, crop rotations may give little visible benefit, whereas the use of fertilizer and lime may produce an appreciable increase in crop growth and production. As part of the sustainable agriculture literature, Granatstein offered legumes in crop rotations as a renewable source of nitrogen. Poincelot pointed out the value of legume forages and cover crops in rotations to provide organic matter as well as nitrogen to the soil and thus to act as an aid in reducing soil erosion. Heichel cited the role of legumes in reducing the fossil fuel energy required in alternative Minnesota corn rotations, as measured by daily "fossil energy flux." Compared with continuous cropping, the fossil energy flux in rotations is reduced as much as 45 percent (Heichel). Crop yields (dry matter basis) are often maintained within a range of plus or minus 10 percent of the mean over the duration of the rotation. Legumes in crop rotations are thus defined as a component of sustainable agriculture.

The control of plant pests and diseases may also be a valid reason for using crop rotations in cotton production. The use of crop rotations as a control measure against diseases sprang from the logical assumption that continuous cropping affords pathogenic organisms a means of continuing their life cycles without interruption. This results in the organisms perpetuation and rapid multiplication. The use of crop rotations for disease control has been demonstrated with root diseases. Probably the most perplexing problem associated with disease control in a crop rotation concerns management. A rotational system designed to reduce disease incidence must also comply with good agronomic practices. Curl emphasized that rarely can the use of rotations completely eliminate a pathogen, but they can reduce the population drastically if the rotated crop does not serve as a host for the disease pathogen.

Several research reports have been published illustrating the effects of crop rotations on the physical and chemical properties of soils. Page and Willard reported declines in crop productivity from continuous cropping of grain crops, including soybean. Georgia research in the 1940's showed that cropping systems which included deep-rooted legumes could affect the drainage and other physical properties of the soil much more than continuous cropping of cotton. The deep-rooted crops were shown to increase porosity and permeability and thus improve soil structure. With better movement of water into the soil profile, run-off and erosion are decreased. Spurgeon and Grissom found in the Mississippi Delta that different cropping systems significantly increased the organic matter content of soils when a sod crop was used, but no difference in bulk density or pH could be detected. With the major emphasis now on row-crop production, most rotations will include some system with combinations of corn, soybean, and/or grain sorghum with cotton as the principal crop. The 1990 Farm Bill encourages the adoption of resource-conserving crop rotations which may include cotton.

Provisions of the Food, Agricultural, Conservation and Trade Act of 1990 (FACTA), including flex acreage requirements, the integrated farm management program (IFM), and the revised 0/92 commodity program, allow farm managers greater planting flexibility. These programs also have the potential to reduce the negative impacts of farming practices on the environment. They can increase the potential to capture the agronomic and environmental benefits of planting a resource-conserving crop as a cover crop or green manure. A resource-conserving crop rotation can reduce erosion, maintain or improve soil fertility and tilth, interrupt pest cycles, and conserve water.

Agronomic research has shown that the long-time cropping systems with varying soil types have significantly affected crop yields in Louisiana (Northeast Research Station). However, the economic research covering alternative crop rotational schemes, varying soil types, and relevant risk factors in a "whole farm" planning analysis has not been done for Louisiana cotton production.

PROBLEM STATEMENT

Conventional continuous cotton production methods in Louisiana have been demonstrated to be inferior, in terms of crop yields, to cotton grown in rotation with other crops (Northeast Research Station). The existence of different soil-types in Louisiana suggests that the optimum utilization of land resources may occur by adopting different cropping systems on different soils. In addition, enterprise diversification can be a major means for managing production variability. Given the variability associated with crop yields from different crop rotations in varying soil types, this study will examine the economic implications, in a risk-return framework, of adopting different crop rotational patterns.

Producers are expected to be the primary beneficiary of this research. This research will provide a general physical and financial framework for estimating costs and returns, as well as risk factors, expected from the use of different cropping systems on different soil types. To the extent that they are concerned with the condition of the environment, the general public will also benefit because this study will address the economic feasibility of crop rotations that emphasize sustainable agricultural practices.

OBJECTIVES

GENERAL OBJECTIVE

The general objective of this research is to determine the relative economic profitability of alternative crop rotational schemes on commerce silt loam and sharkey clay soils in northeast Louisiana. Alternative rotations include: two-years cotton-corn or three-years cotton-sorghum-soybean on commerce silt loam, and two-years soybean-grain sorghum or two-years soybean/wheat-sorghum/wheat on sharkey clay.

SPECIFIC OBJECTIVES

1. Determine costs and returns for selected combinations of rotational patterns and soil type.

2. Determine the economic performance, in a risk-return framework, of selected rotational patterns within a whole farm context.

JUSTIFICATION

Cotton production is a major component of Louisiana's agricultural production sector. Cotton represented 23 percent and 19 percent of total receipts from livestock and crop enterprises in 1992 and 1993, respectively (Zapata and Frank). In terms of receipts from crops only, cotton accounted for 34 percent in 1992 and 32 percent in 1993 (Zapata and Frank). As a joint consequence of the government price support program for cotton, an increase in the demand for cotton, and lower prices for soybeans and other competing crops, cotton acreage has expanded dramatically in recent years. In 1980, total cotton acreage in the state was 570,000 acres. By 1993, the total had increased to 890,000 acres, representing a 56 percent increase over 1980 acreage.

If cotton acreage in Louisiana continues to increase, the environmental impacts associated with cotton production will increase proportionately, as will the possibility of increased regulation of production systems. Because of growing public concern about soil erosion, groundwater contamination, and protection of the environment in general, it is critical that both producers and policy makers have reliable information regarding farm-level impacts of alternative cotton production systems.

Additional impetus for this research stems from the current emphasis on sustainable agricultural production system. Several alternative definitions of sustainable agriculture exist. However, all seem to agree that the definition includes reductions in reliance on nonrenewable inputs, such as petroleum-based fertilizer and pesticide products; reductions in reliance on externally produced inputs; reductions in environmental degradation; and an increase in management input (Novak, Mitchell, and Crew). Crop rotations have been shown to contribute to sustainable agriculture by maintaining soil productivity, controlling plant diseases, controlling soil erosion (Martin, Leonard, and Stamp).

While policy makers are more interested in the sustainability aspect of production systems, producers are mainly interested in the profitability of the systems. From the producers' viewpoint, the question is which system is best for which soil type and cropping regime? Government programs have been a constraint on certain rotations. For example, cotton and corn work well in a rotational scheme - however they are both considered program crops and as such there are restrictions on the use of these crops on the same farm (assuming farmers want to maintain eligibility for the program benefits). Future programs are expected to increase incentives for farmers to adopt environmentally friendly production systems. Given this scenario, there is a need to know which system are best suited for a given resource situation. Research on the economic aspects of resource-conserving crop rotations is needed to identify the economic potential of alternative rotational patterns. Such information is needed to enhance the adoption of these practices by producers.

LITERATURE REVIEW

Risk efficiency in farm planning has received a great deal of treatment in the economics literature. Risk analysis as applied to crop rotations, especially as applied to sustainable agriculture, has not been widely discussed.

Research of this particular type has not been attempted in Louisiana. A review of published research suggests that researchers in other states have been concerned with various dimensions of the crop rotation question.

Keeling et al. evaluated conservation tillage systems on the Texas Southern High Plains. The study utilized experimental results from plots at Lubbock and Halfway, which included three crop regimes: (1) continuous cotton, conventional tillage, (2) continuous cotton, conservation tillage, and (3) wheat-cotton conservation tillage, in which the wheat was used as a cover crop and terminated in April. Each crop regime was evaluated under both irrigated and nonirrigated conditions. Conservation tillage systems yielded higher net revenues (over total costs) than conventional methods under both irrigated and nonirrigated conditions for the two-year study (1986-1987). While the study evaluated the relative economic feasibility of each system, a lack of data due to the short time span covered by the study did not allow for an assessment of risks inherent with each system nor a comprehensive economic evaluation of each system.

Over time, a number of risk efficiency criteria have appeared in the literature. Perhaps the most common is stochastic dominance analysis, which provides a means of selecting alternatives that are optimal, according to expected utility maximization, for a specified set of utility functions. Brown used stochastic dominance to define risk efficient sets of alternative wheat, canola, and lentil rotations in order to describe more effectively Saskatchewan producer behavior with respect to actual rotation choices. He stated the case for using stochastic dominance over alternative methods (particularly, mean variance trade off approach) for selecting the most risk-efficient rotation.

Zacharias and Grube used stochastic dominance to evaluate the effect of weed control and alternative crop rotations on distributions of net returns in Illinois. They explicitly stated that the alternative weed control-crop rotations are discrete systems. Their results indicate that, regardless of the weed control method, a rotation of two years corn and one year soybeans was the most preferred. Systems which substituted cultivation for herbicide use were least preferred. Successively alternating herbicides on an annual basis as compared to applying a single major herbicide was found to increase both net returns and risks.

Olson et al. evaluated the introduction of an annual alfalfa into a corn-soybean farming system. The economic returns of annual alfalfa were compared with the returns from corn and soybean at the enterprise and whole farm levels. The incorporation decision for an individual farmer was exemplified in a case farm and extended to a larger class of farms by use of risk analysis. Differences in the variability of net returns between systems were analyzed by the rules of stochastic dominance. The rotations considered were corn-soybean (CS), corn-alfalfa (CA), and corn-soybean-corn-alfalfa (CSCA). Important factors considered were profit levels, yield risks in terms of both quantity and quality, price risk, labor requirements, machinery requirements, management knowledge, and environmental impacts. Using owned equipment, the expected return for the CS rotation was \$100/acre; for the CA rotation was \$115/acre, and for the CSCA was \$98/acre. Adding risk to the decision process shows that an individual risk averse farmer with owned equipment would choose CSCA rotation. However stochastic dominance can not be applied directly in programming models (Boisvert and McCarl). An alternative mathematical programming, Target MOTAD (developed by Tauer) is computationally efficient and generates solutions meeting the second-degree stochastic test.

Zwingli et al. analyzed the potential profitability of vegetable crop production for farmers in the northern region of Alabama. A mixed integer linear programming model was developed to simulate the decision environment faced by an entry-level vegetable producer contemplating production for the wholesale market. A Target MOTAD analysis, as developed by Tauer, was utilized so that the risk associated with price-related income variability could be incorporated into the mixed-integer programming model. The model included activities which permitted consideration of 13 vegetables within a spring, summer, and fall rotational system. Rotations were permitted within the bounds established by marketing, rotational, and price risk constraints. Rotations were generally stable with respect to markets and crop mixes as target income and acceptable negative deviation levels were varied. Spring and fall broccoli and turnip greens and late spring-summer yellow and zucchini squash were dominant crops in the triple crop rotations in the Atlanta and Cincinnati markets.

Novak et al. analyzed sustainable cotton rotations by employing the Target MOTAD method. Ten years of yield data from the "old rotation" agronomic cotton production study at Auburn University and enterprise budgets were used to estimate costs and returns. The researchers examined the economic feasibility of six different rotations with respect to a target level of income and the levels of risk associated with the different levels of income. The six rotational schemes used in the study were: (1) continuous cotton, winter legumes, no nitrogen fertilizer (CtL), (2) continuous cotton, no legumes, no nitrogen fertilizer (Ct), (3) continuous cotton, 120 lbs. of nitrogen per acre (CtN), (4) two-years cotton-corn, winter legumes, no nitrogen fertilizer (CtLCn), (5) two-years cotton-corn, winter legumes, 120 lbs. of nitrogen per acre on each crop (CtLCnN), (6) three-years cotton-corn-rye/soybeans, winter legumes after cotton, 60 lbs. of nitrogen fertilizer per acre on rye (CtLCnS). Novak et al. found that rotations including winter legumes outperformed rotations that included only nitrogen fertilizer by providing higher expected returns with less risk, for all levels of target income modelled. A combination of the CtLCnS and CtL rotations, rather than a single cotton rotation scheme, resulted in a least risk plan for all levels of target income.

PROCEDURES

GENERAL PROCEDURE

The initial step in this study was to determine the costs and returns of various crop rotations in cotton production and enterprise budgets. These budgets were based on physical data from an ongoing crop rotational study at the Northeast Research Station.

Net revenue comparisons were made between enterprise budgets for different crop rotational schemes, thereby identifying the economically profitable set of production systems. The returns were defined as net returns above variable costs.

The data on physical relationships and cultural practices for all the production systems used in this analysis were secured from the Northeast Research Station. The cropping systems study was instituted at the Northeast Research Station in 1982. The enterprise budgets for alternative crop rotational schemes were based on cultural practices at the Northeast Station. These budgets were constructed using the Mississippi State Budget Generator (MSBG). Unit input prices were held constant at 1993 levels, while yields varied with annual experimental plot results (Klemme). The sources of variability in the net returns are variability in the crop yields, crop prices on the revenue side, and variability in the input costs. The experiment station within the nonprofit environment, is more concerned with the maximization of crop yields than minimization of cost. The approach adopted in the present study served to isolate stochastic changes in net returns due to yield and output price variations only. Crop prices were estimated using Agricultural Statistics and Prices for Louisiana and the USDA's Agricultural Outlook estimates of deficiency payments on farm program crops.

The yield data provided by the Northeast Research Station was expressed in pounds of seed cotton per acre. The yields, in terms of pounds of seed cotton, were converted to pounds of lint and cotton seed using data published by the USDA-ERS for Louisiana for the 1993-1994 season.

PROCEDURE FOR OBJECTIVE 1

Costs and returns for each cropping system were estimated using the Mississippi State Budget Generator (MSBG). Enterprise budgets were based on data obtained from the 11 year study of crop rotations at Northeast Research Station. These budgets were prepared for each system for each year. Price deficiency payments based on the current government program were included in the gross return estimates (following Vandeveer et al., Novak et al. and Olson et al.). Since many of the crops in the rotations were covered by various government programs, the model farm was assumed to participate in those programs. Further, it was assumed that sufficient base acreage was available to produce the program crops. The resulting enterprise budgets revealed the economic feasibility of each system over the 11 year period. Data associated with yields and cultural practices for selected rotational patterns were based on annual research reports from the Northeast Research Station.

Implicit costs, such as the discounted loss in future yields due to soil erosion, were not included in the enterprise budgets. The rationale behind this omission is that a representative farm would not include these costs in his own budget (i.e., a producer views them as a nonmonetary cost).

PROCEDURE FOR OBJECTIVE 2

Target MOTAD programming procedures were used to analyze and evaluate the effect of farm's economic performance. Only those crop rotations which resulted in average annual positive net returns above variable costs were included in the objective function. Technical resource constraints included land, labor, and the deviations from target income. Deviation constraints related returns per period to the target income level. In this model it was assumed that negative deviations (Z_t^-) for each state of nature were equally likely (P_t). In a Target MOTAD model, risk (G) is defined in terms of expected value of total negative deviations from target income i.e. $\Sigma_t P_t Z_t^- = G$. If we consider the number of states of nature N (t=1..N) where the probability associated with each state is P_t ($\Sigma_t P_t = 1$) then $\Sigma_t (1/N) Z_t^- = G$. The term 1/N is then viewed as the probability of state of nature t i.e. $P_t = 1/N$. Therefore, in our model probability was assumed to be equal across the states of nature. Observations on the distributions of net returns over time were developed using yields from the historic data. Probabilities on these states of nature were assumed to be equally likely.

CHAPTER 2
THEORETICAL BACKGROUND

Agricultural production occurs in a risky environment. The biological nature of crop and livestock production, interacting with variable weather and environmental conditions, and changing demand, as well as unpredictable government policies, affects agricultural prices and can lead to wide year-to year and seasonal swings in agricultural incomes and the well being of farm decision makers. The analysis of farm-level decisions under risk has been prominent in the agricultural economics literature. Within this category, decision theory has dominated. It suggests that the maximization of satisfaction or utility is the appropriate criterion upon which to make decisions under risk. The expected utility model, which is based on the existence of an ordinal utility function by which alternatives can be ranked, becomes the basis for decision analysis under risk.

EXPECTED UTILITY MODEL

The expected utility model is based on a theorem derived from a set of axioms about individual behavior. A complete development of the approach is found in the works of von Neumann and Morgenstern or Luce and Raiffa. The most important axioms are summarized as follows:

1. Ordering: For two choices A_1 and A_2, decision maker either prefers A_1 to A_2, prefers A_2 to A_1, is indifferent.

2. Transitivity: If A_1 is preferred to A_2, and A_2 is preferred to A_3, then A_1 must be preferred to A_3.

3. Continuity: If A_1 is preferred to A_2, and A_2 is preferred to A_3, then there is a mixture of A_1 and A_3 that is preferred to A_2 and a mixture of A_1 and A_3 over which A_2 is preferred.

4. Independence: If A_1 is preferred to A_2 and A_3 is any other prospect, then the individual will prefer a mixture of A_1 and A_3 to the same mixture of A_2 and A_3.

If the above axioms hold, the theorem follows that an optimal risky choice is based on the maximization of expected utility. Suppose a decision maker is faced with the problem of choosing among alternative courses of action, the outcomes from which are determined by the state of an uncertain environment where:

A_j = the j^{th} act or alternative course of action;

s_i = the i^{th} possible risky outcome;

$p_i = P(s_i)$ = the probability that s_i occurs; and

y_{ij} = the outcome of A_j given that s_i occurs.

Then, for the utility function $U(y)$, we know:

a) if any risky action, A_1 is preferred to another, A_2, then $U(A_1) > U(A_2)$, and b) $U(A_j) = E_i[U(y_{ij})] = \Sigma_i p_i U(y_{ij})$.

Following expected utility theory, the optimal act, A_j^*, is the one which maximizes expected utility (Anderson, Dillon, and Hardaker): $EU(A_j^*) = \text{Max } U(A_j) = \text{Max } [\Sigma_i p_i U(y_{ij})]$.

This theory, therefore ranks alternatives according to the probability of states of nature occurring, and relative preferences regarding outcomes as represented in the utility function.

RISK ATTITUDES

A decision maker's attitude toward risk is inferred from the shape of his utility function. A linear utility function implies risk neutrality (Figure 2.1), a convex function implies risk preferring attitude (Figure 2.2), and a concave function implies risk aversion (Figure 2.3). There may exist a utility function with both convex and concave segments indicating changes in risk attitudes. Attitudes toward risk vary, depending very much on the psychological make-up of the risk-taker and the probable outcomes.

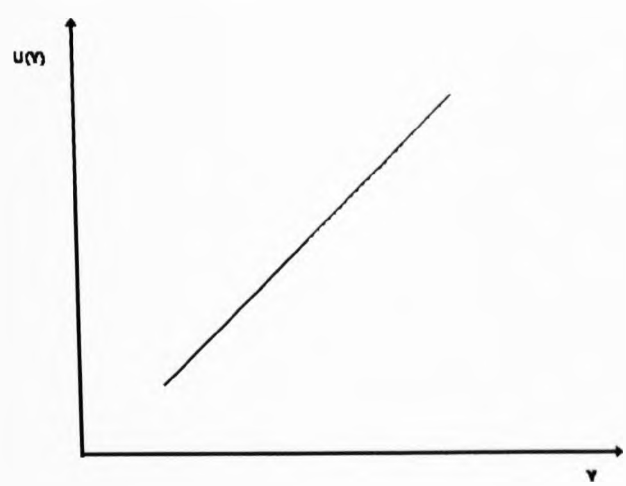

Figure 2.1: Risk Neutral. Constant Marginal Utility of Income

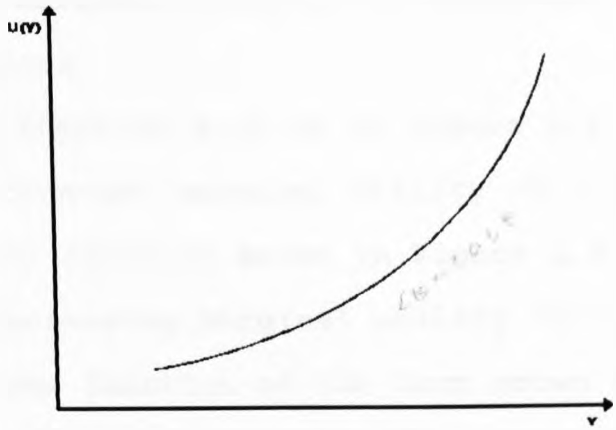

Figure 2.2: Risk Preferring. Increasing Marginal Utility of Income

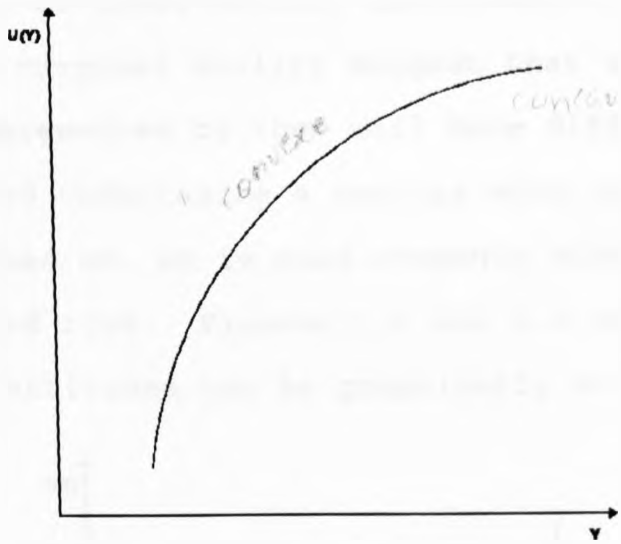

Figure 2.3: Risk Averse. Decreasing Marginal Utility of Income

The variable in this study that affects utility is income (Y). Figures 2.1, 2.2, and 2.3 show the utility of income curves for representative individuals, with income on X-axis, and utility on the Y-axis. In all three figures, as income increases, so does total utility. However the rate at which utility is increasing per additional dollar of income, or the marginal utility, is different for each type of risk preference.

A utility function such as in Figure 2.1, exhibits positive, and constant marginal utility (U'= constant, U'' = 0). The utility function shown in Figure 2.2 yields positive and increasing marginal utility (U'>0, U''>0). A utility of income function of the form shown in Figure 2.3 is associated with positive, but decreasing marginal utility(U'>0, U''<0) for each additional dollar of income.

The shapes of these utility curves and their respective differences in marginal utility suggest that each of the individuals represented by them will have different attitudes toward undertaking a venture with uncertain monetary outcomes or, as is more commonly stated, different attitudes toward risk. Figures 2.4 and 2.5 show how these types of risk attitudes can be graphically evaluated.

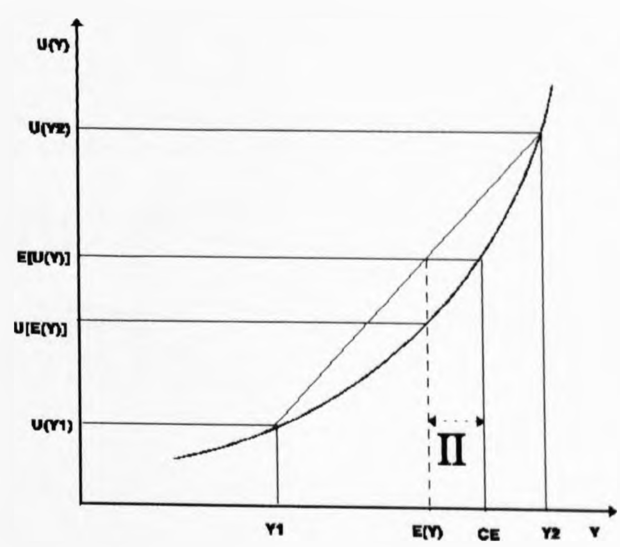

Figure 2.4: Risk Premium for Risk Preferring Decision Maker

Figure 2.4 shows an individual with increasing marginal utility of income, or a risk taker. Without taking a gamble, he is assured of achieving the level of income denoted by CE (certainty equivalent) and the corresponding level of utility E[U(Y)]. The gamble has two monetary outcomes denoted by Y1 (probability p_1) and Y2 (probability $p_2 = 1 - p_1$). The levels of utility associated with these outcomes are U(Y1) and U(Y2) respectively. The expected outcome E(Y) is equal to (p_1Y1 + p_2Y2). As can be seen from Figure 2.4, when the utility function is convex, the expected utility of the gamble, E[U(Y)] is greater than the utility of the expected outcome, U[E(Y)]. The certainty equivalent, CE, is the amount, in units of Y, that will give the same utility as the gamble itself (i.e. U(CE) = E[U(Y]. Pratt's risk premium (Π) is calculated as Π = E(Y) - CE. In economic parlance, the risk premium is conceptualized as that part of the return to fixed and net working capital in an uncertain world, which compensates the owners of capital for the risk involved in its use in profit seeking ventures.

For a risk taker, Π is negative, meaning that this individual is willing to pay to take the gamble, and therefore have the chance of increasing his level of utility to U(Y2). Of course, there is also the chance that the gamble will fail and his level of utility will fall to U(Y1), but he is still willing to take the gamble.

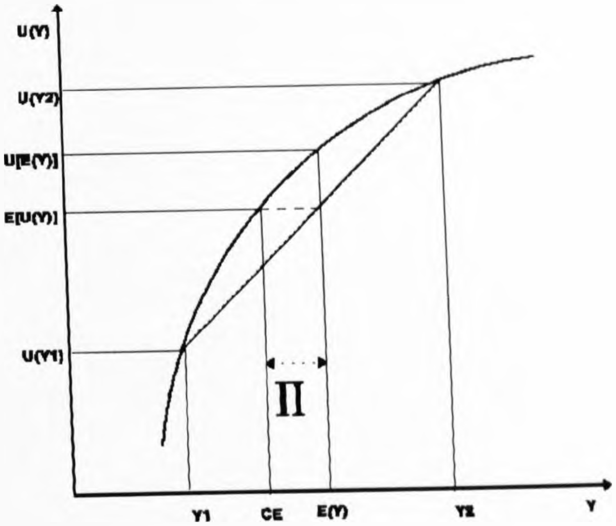

Figure 2.5: Risk Premium for a Risk Averse Decision Maker

Figure 2.5 shows the utility of income for an individual with decreasing, but still positive, marginal utility of income, i.e. a risk averter. With the same label definitions and formula for Π given above, it is evident, because Π is positive, that in order for this individual to take the risk, he would have to receive a payment equal to Π.

Agricultural production is generally a risky process. Variability in crop yields, output and input prices and other factors contribute to variability in farmers' income. Some evidence of risk-averse behavior of farmers has been documented (Just; Behrman; Anderson, Dillon, and Hardaker).

RISK PROGRAMMING MODEL

Some risk programming models are direct applications of expected utility theory and attempt to identify a single optimal decision given the utility function which is generally specified as a quadratic function. Direct applications are suitable when preferences are known and can be precisely formulated, but in applied problems preferences are rarely known, are difficult to measure, and are unique to decision makers.

Another approach to decision making under risk is to develop sets of efficient solutions. This approach, often called risk efficiency analysis, is based on the utility maximization framework but does not require the full specification of the utility function.

The most commonly used efficiency criterion is the mean-variance (E-V) trade off. The E-V criterion is based on the proposition that, given two distributions with equal means, a risk averter will prefer the distribution with the smallest variance (risk). The E-V approach suggests that decisions can be ranked solely in terms of the first moment (mean) and second moment (variance) of the normal distribution. However, distributions of alternative net income exhibiting skewness and higher moments are common in agricultural situations (Barry). Therefore, efficiency criteria that consider the total distribution of outcomes rather than two summary statistics are preferred.

Stochastic dominance criteria consider the total distribution of net returns. As the degree of stochastic efficiency increases, the restrictive assumptions on the utility function also increase. First-degree stochastic dominance (FSD) assumes decision makers prefer more to less (positive marginal utility of income(y)). The FSD ordering rule for two risky prospects F and G having cumulative frequency distribution functions F(y) and G(y) is: F dominates G if, $F(y) \leq G(y)$ for all y, and $F(y) < G(y)$ for at least one y. The second degree stochastic dominance assumes decision makers are risk averse (positive but decreasing marginal utility of y). The SSD ordering rule is: F dominates G if, $F_2(y) \leq G_2(y)$ for all y, and $F_2(y) < G_2(y)$ for at least one y, where

$$F_2(y) = \int_0^y F(y)\, dy$$

and,

$$G_2(y) = \int_0^y G(y)\, dy$$

Because stochastic dominance places few restrictions on the utility function and none on the probability distributions, it has some theoretical advantages over the E-V approach. Unfortunately, stochastic dominance can not be applied directly in programming models (Boisvert and McCarl). Moreover, the stochastic dominance approach is unable to select combinations of the modelled systems as the optimal risk-efficient set of crop rotations (Novak et al.).

Because quadratic programming models are harder to solve than linear programs, Hazell and Norton introduced Minimization of Total Absolute Deviations (MOTAD) model, which is the linear programming approximation to the E-V model. The model is specified as follows:

(1) $\text{MIN } \Sigma_t (Z_t^+ + Z_t^-)$,

subject to:

(2) $\Sigma_j (c_{jt} - c_j) X_j - Z_t^+ + Z_t^- = 0$, for all t,

and:

(3) $\Sigma_j c_j X_j = E$,

(4) $\Sigma_j a_{ij} X_j \leq b_i$, for all i,

(5) $X_j,\ Z_t^+,\ Z_t^- \geq 0$, for all j, t,

where:

c_{jt} = the return from enterprise j in period t;

c_j = the expected return from enterprise j;

X_j = the level of enterprise j;

Z_t^+ = positive deviation of return from mean in period t;

Z_t^- = negative deviation of return from mean in period t;

b_i = total availability of resource i;

a_{ij} = requirement of resource i by one unit of enterprise j; and,

E = expected total return.

Because MOTAD is a linear approximation to the E-V model, the limitations of E-V model are also applicable to

MOTAD model. Moreover, most producers are concerned with deviations in income below an expected level, and not with absolute deviation about the mean income level, as addressed by the MOTAD model. A more promising programming formulation combining the target income and MOTAD concepts is the so-called Target MOTAD model developed by Tauer.

Target MOTAD is an extension of MOTAD, within a safety first framework (Hazell and Norton). Safety first models are designed to help ensure that the decision maker attains the minimum income necessary to meet fixed and living costs. In this study Target MOTAD model is used to determine the set of feasible risk-minimizing crop rotations from a set of profitable crop rotations. Target MOTAD was chosen over other possible methods because of its practical and theoretical appeal and because of the ability to examine optimal combinations of rotations. According to Boisvert and McCarl, Target MOTAD model is consistent with expected utility theory. The Target MOTAD model allows for the comparison of alternative farm scenarios at a common level of risk (Watts et al.). As demonstrated by Tauer, Target MOTAD results are second-degree stochastic dominant. The Target MOTAD model can be formulated as follows:

(6) $\text{Max } E(\text{Return}) = \boldsymbol{\Sigma}_j c_j X_j$,

subject to:

(7) $T - \boldsymbol{\Sigma}_j c_{jt} X_j - Z_t^- \leq 0$, for all t,

(8) $\boldsymbol{\Sigma}_t P_t Z_t^- = G$,

(9) $\Sigma_j a_{ij} X_j \leq b_i$, for all i,

(10) X_j, $Z_t^- \geq 0$, for all j, t,

where E(Return) is the expected return from the optimal plan, T represents target income level, Z_t^- represents a deviation below the target income level, P_t represents a probability of state of nature t, and G is a risk constant parameterized to vary from 0 to some large number.

The model is set up to maximize expected return subject to achieving a satisfactory level of compliance with target income (T). A set of efficient farm plans is obtained by parameterizing the level of risk (G) from the arbitrarily large number to 0 (equation 8). The resulting farm plans maximize expected returns for a given risk level, subject to the minimized negative deviations from T. Changes are made in the value of G and optimal solutions are obtained until all feasible possible changes in basis occur, and the value of expected net return can not be improved by increasing the level of risk.

CHAPTER 3
COLLECTION AND INVESTIGATION OF DATA

The primary data set for this study consists of crop yield data collected from an ongoing crop rotation study conducted by scientists at the Northeast Research Station, St. Joseph, Louisiana. Output price data were obtained from a database available in the Department (Microcomputer Implemented Louisiana Agricultural Statistics (MILAS)).

The experiments on cropping systems were initiated in 1982 on commerce silt loam and sharkey clay soils. Both soil treatments were laid out in a randomized complete block design with four replications. On the silt loam soil, plots consisted of 16 40-inch rows that were 50 feet long. On the sharkey clay soil, plots were 27 feet wide and 120 feet in length. The unit of observations was individual replications from each plot. There were a total of 48 possible observations (4 replications per year over a 12 year period). Because the plots were small, yield measurement errors, if any, may be amplified in extrapolating plot yields to yields per acre of land. However, for purposes of this analysis, such under and over estimates in measurement were assumed to cancel one another.

The original experiment included 13 cropping systems on commerce silt loam soil, and 8 cropping systems on sharkey clay soil. However, yield data from systems involving grain sorghum were incomplete due to bird depredation and were excluded from the present analysis. Systems involving summer fallow were excluded because annual returns from these systems were low. For the present study, 11 cropping patterns were selected for inclusion in the analysis. Table 3.1 shows the selected cropping schemes on two soil types.

Table 3.1: Selected Cropping Schemes, Northeast Research Station, Louisiana, 1983-1993.

A. Commerce Silt Loam Soil (CSL):
   1. Continuous Cotton (CSL1)
   2. Continuous Soybean (CSL2)
   3. Continuous Corn (CSL3)
   4. Cotton-Corn (CSL4)
   5. Corn-Soybean (CSL5)
   6. Cotton-Soybean (CSL6)
   7. Cotton-Corn-Soybean (CSL7)
   8. Cotton-Cotton-Soybean (CSL8)
   9. Cotton-Cotton-Corn (CSL9)

B. Sharkey Clay Soil(SC):
   1. Continuous soybean (SC10)
   2. Continuous Soybean-Wheat Double Crop (SC11)

Table 3.2 shows summary statistics associated with individual crop yields within the selected rotational system on both soil types. Cotton yields have wide ranges with comparable coefficient of variations in the 20's. Soybean yields exhibit relatively wide ranges and the coefficient of variation indicates a high degree of variability in yields. Corn yields have low ranges with low coefficients of variation in the 10's. Yields of the wheat enterprise have a wide range and the highest coefficient of variation among the enterprises included in this analysis.

Table 3.2: Average Crop Yields for Selected Rotations, Northeast Research Station, La. 1983-1993.

ROTATION[a]	CROP	NO[b]	UNIT	MEAN	SD	CV(%)	RANGE
CSL1	Cotton[c]	44	lbs/a	1109.51	305.75	27.56	1476
CSL2	Soybean	44	bu/a	45.43	11.75	25.86	75
CSL3	Corn	44	bu/a	134.86	26.58	19.71	101
CSL4	Cotton	24	lbs/a	1237.04	273.79	22.13	985
CSL4	Corn	20	bu/a	149.30	24.48	16.39	85
CSL5	Corn	20	bu/a	148.95	24.49	16.44	89
CSL5	Soybean	24	bu/a	54.83	8.59	15.67	31
CSL6	Cotton	20	lbs/a	1252.23	359.64	28.69	1208
CSL6	Soybean	24	bu/a	54.75	6.92	12.64	28
CSL7	Cotton	12	lbs/a	926.09	245.10	26.47	774
CSL7	Corn	16	bu/a	152.94	26.75	17.48	97
CSL7	Soybean	16	bu/a	57.25	8.33	14.55	27
CSL8	Cotton	28	lbs/a	1073.46	218.98	20.40	878
CSL8	Soybean	16	bu/a	56.50	7.16	12.68	20
CSL9	Cotton	28	lbs/a	1074.41	240.43	22.37	966
CSL9	Corn	16	bu/a	156.31	24.06	15.39	73
SC10	Soybean	44	bu/a	33.97	9.23	27.19	37
SC11	Soybean	44	bu/a	30.33	8.87	29.24	30
SC11	Wheat	40	bu/a	34.10	16.84	49.38	56

[a] The crops involved in the rotations are defined in Table 3.1.
[b] Number of observations.
[c] Pounds of lint cotton. Yield data provided by the Northeast Research Station were expressed in pounds of seed cotton per acre. Seed cotton yields were multiplied by 38% to convert to pounds of lint cotton. The percentage was based on data published by the department (Paxton).

Table 3.3 shows, in descending order, mean yields for cotton and other crops included in the study. The mean yield from continuous cotton (CSL1) was higher than mean yields of cotton in three crop rotations (CSL7, CSL8, and CSL9), but lower than mean yields of cotton in two crops rotations (CSL4 and CSL6). Mean soybean yields were lower on sharkey clay soil than on commerce silt loam soil. Mean yields for all row crops were higher when the crop was grown in rotation than when grown in a monocropping environment.

Table 3.3: Ranking of Mean Crop Yields In Selected Rotations, North East Research Station, Louisiana, 1983-1993

Rank	Crops			
	Cotton	Soybean	Corn	Wheat
	Cropping Regimes[a]			
1	CSL6	CSL7	CSL9	SC11
2	CSL4	CSL8	CSL7	
3	CSL1	CSL5	CSL4	
4	CSL9	CSL6	CSL5	
5	CSL8	CSL2	CSL3	
6	CSL7	SC10		
7		SC11		

[a] The crops involved in the regimes are defined in Table 3.1.

The time series yield data for each crop was evaluated to determine if there was a trend in the data. During the study period, scientists used the best available technology, progressively better crop varieties, herbicides, and insecticides as they became available in the open market. The use of improved inputs could have contributed to an upward trend in crop yields. On the other hand, changes in organic matter, nematode population, biomass and drymatter production, topsoil erosion, and other agronomic variables, could also affect yield increases from improved varieties.

In order to identify any linear or curvilinear trends, yields were regressed on time and the natural logarithm of time, a non-linear transformation. Results of the analysis are shown in Table 3.4. Seven of the enterprises exhibited linear trend significant at the five percent level. Three of these were also significant at the one percent level. Five of the seven enterprises were soybean enterprises while the remaining two were cotton and corn. Four enterprises exhibited the presence of curvilinear trend. Three of the four (CSL7, CSL9, and SC10) also had significant linear trend. While wheat did not have statistically significant linear trend, curvilinear trend was significant at the five percent level.

Previous studies in crop rotations have not generally addressed the issue of trend in crop yields and/or prices. While many similar studies used data from experiments of shorter duration than the present study, others used a similar time frame. For example, Novak, Mitchell, and Crews used 10 years of crop yield data for their rotation study. They argued that structural changes due to changing hybrids, machinery, and pest control, are minimized by limiting the data used to this time period. Consequently, they did not consider analyzing trends. Another reason behind omission of trend analysis in the rotation study may be the learning curve effect. The full effect of rotations on a crop yield may be seen only after the rotation study takes place a considerable number of years.

Table 3.4: Summary Results of Linear and Curvilinear Trend Analysis for Crops in Selected Rotations, Northeast Research Station, 1983-1993. **Bold characterizes significance at 5% level**

ROTATION[a]	CROP	NO[b]	CRITICAL VALUES[c] 5%	1%	CALCULATED VALUS LINEAR[d]	CURVILINEAR[d]
CSL1	Cotton	44	1.960	2.580	0.231	-0.667
CSL2^	Soybean	44	1.960	2.580	**2.181**	-1.758
CSL3	Corn	44	1.960	2.580	-1.508	1.270
CSL4	Cotton	24	2.070	2.820	-0.770	0.600
CSL4	Corn	20	2.100	2.880	1.771	-0.625
CSL5	Corn	20	2.100	2.880	1.295	-0.590
CSL5^	Soybean	24	2.070	2.820	**3.122***	-1.732
CSL6	Cotton	20	2.100	2.880	1.274	-1.676
CSL6^	Soybean	24	2.070	2.820	**3.013***	-1.671
CSL7^	Cotton	12	2.230	3.170	**2.882**	**-2.245**
CSL7	Corn	16	2.140	2.980	-0.102	0.533
CSL7^	Soybean	16	2.140	2.980	**2.345**	-1.019
CSL8	Cotton	28	2.060	2.780	1.796	-1.588
CSL8^	Soybean	16	2.140	2.980	2.038	-0.552
CSL9	Cotton	28	2.060	2.780	0.354	-0.183
CSL9^	Corn	16	2.140	2.980	**-2.551**	**2.680**
SC10^	Soybean	44	1.960	2.580	**2.932***	**-4.031***
SC11	Soybean	44	1.960	2.580	-0.568	-0.240
SC11^	Wheat	40	1.960	2.580	0.863	**-2.425**

[a] Each rotation is identified in Table 3.1.
[b] Number of Observations
[c] Critical Values are reported at 5% and 1% significance levels corresponding to two-tailed test.
[d] T Statistics generated in trend analysis.
* Asterisk represents significance at 1% level.
^ The crops in the rotation exhibiting presence of trends.

In the present study the crop yield data were tested for the presence of trends as described above. Given the results shown above, detrending procedures were applied to the data to remove the effect of trend. The detrended yield data were expected to have the same means with less variability. The net effect of removing trend from the data would be to isolate the variability due to the rotational pattern.

From the regression of yields over time and natural logarithm of time, the residuals corresponding to each observation were collected assuming that the unexplained variations around the mean yield data were captured in the error term in the regression model(SAS/ETS Users Guide). The positive(negative) residuals corresponding to each observation of each regression model were added(subtracted) to the corresponding mean crop yield data to obtain detrended yield data series. Table 3.5 shows the summary statistics associated with detrended yield data.

Table 3.5: Average Detrended Crop Yields for Selected Rotations, Northeast Research Station, Louisiana, 1983-1993.

ROTATION[a]	CROP	NO[b]	UNIT	MEAN	SD	CV(%)	RANGE
CSL2	Soybean	44	bu/a	45.43	11.08	24.39	67
CSL5	Soybean	24	bu/a	54.83	6.20	11.32	28
CSL6	Soybean	24	bu/a	54.75	5.08	9.28	20
CSL1	Cotton[c]	44	lbs/a	926.09	166.44	17.97	586
CSL7	Soybean	16	bu/a	57.25	5.48	9.57	24
CSL8	Soybean	16	bu/a	56.50	4.53	8.03	17
CSL9	Corn	16	bu/a	156.31	19.29	12.34	66
SC10	Soybean	44	bu/a	33.97	7.59	22.36	31
SC11	Wheat	40	bu/a	34.10	14.01	41.09	53

[a] The crops involved in the rotations are defined in Table 3.1.
[b] Number of observations.
[c] Pounds of lint cotton. Yield data provided by the Northeast Research Station were expressed in pounds of seed cotton per acre. Seed cotton yields were multiplied by 38% to convert to pounds of lint cotton. The percentage was based on data published by the department (Paxton).

Comparing Table 3.5 with Table 3.2 it is apparent that means did not change and the standard deviation(SD), coefficient of variations(CV), and range were decreased as expected from a set of detrended data. Detrended yield data plotted against time did not indicate any presence of trend.

Crop yield data from the ongoing research of the Northeast Research Station used in this analysis covers 11 year period from 1983 through 1993. Annual price data for the selected crops viz. cotton lint, cotton seed, corn, wheat, soybean were obtained from MILAS. All the prices were adjusted using producer price index (PPI) for all commodities with 1993 as the base year. The justification for selecting 1993 as the base year for the revenue side was that the variable costs of production were expressed in 1993 dollars.

Table 3.6: Mean, Standard Deviations (SD), Coefficient of Variations (CV) of Prices Adjusted to 1993 Price Level, Louisiana, 1983-1993.

PRODUCT	UNIT	Mean	SD	CV(%)	RANGE
Cotton Lint	$/lbs	0.63	0.07	11.36	0.23
Cotton Seed	$/ton	100.56	38.59	38.37	145.43
Corn	$/bu	2.87	0.64	22.38	2.14
Wheat	$/bu	3.59	0.48	12.57	1.41
Soybean	$/bu	6.64	1.06	15.96	3.36

Summary statistics for the deflated prices are reported in Table 3.6. From Table 3.6 it is apparent that the price of cotton seed was more variable than the price of cotton lint over the period. Other products had less variability with relatively low ranges.

The next data characteristic investigated was the distribution of yields and prices. The distribution of the data is important because it influences the choice of analytical model. This investigation was restricted to the normal distribution. The "Proc Univariate" statement in SAS 6.02 was used to test normality of the yields and prices. When the "Normal" option is specified, the univariate procedure generates a test statistic for the null hypothesis that the input data are a random sample from a normal distribution. The test statistic (Shapiro-Wilk, W) compares the shape of the sample distribution with the shape of a normal distribution. The alternative hypothesis is that the data are not normally distributed. The decision rule is to not reject the null if the computed W is greater than the Shapiro Wilk critical value or to reject the null hypothesis if the computed W is less than the Shapiro-Wilk critical value at a given level of significance (Pearson and Hartley). If the sample size is less than fifty one, the W is computed. The W statistic is the ratio of the best estimator of the variance (based on the square of a linear combination of the order statistics) to the usual corrected sum of squares estimator of variance. W must be greater than zero and less than or equal to one. The W statistics and corresponding critical values are reported in Table 3.7 and 3.8.

Table 3.7: Test for Normality of Yield Distributions.

ROTATION	CROP	NO[a]	W Statistic	CRITICAL VALUE[b]
CSL1	Cotton	44	**0.979**	**0.944**
CSL2	Soybean	44	0.904	0.944
CSL3	Corn	44	**0.961**	**0.944**
CSL4	Cotton	24	**0.945**	**0.916**
CSL4	Corn	20	**0.946**	**0.920**
CSL5	Corn	20	**0.980**	**0.905**
CSL5	Soybean	24	**0.965**	**0.916**
CSL6	Cotton	20	**0.912**	**0.905**
CSL6	Soybean	24	**0.962**	**0.916**
CSL7	Cotton	12	**0.927**	**0.859**
CSL7	Corn	16	**0.980**	**0.887**
CSL7	Soybean	16	**0.909**	**0.887**
CSL8	Cotton	28	**0.943**	**0.924**
CSL8	Soybean	16	**0.987**	**0.887**
CSL9	Cotton	28	**0.942**	**0.924**
CSL9	Corn	16	**0.926**	**0.887**
SC10	Soybean	44	**0.976**	**0.944**
SC11	Soybean	44	**0.945**	**0.944**
SC11	Wheat	44	0.910	0.944

[a] Number of Observations.
[b] At 5% significance level.
Bold characterizes failure to reject null hypothesis that sample is from normal distribution.

Table 3.8: Test for Normality of Price Distributions.

PRODUCT	W Statistic	CRITICAL VALUE[a]
Cotton Lint	**0.972**	**0.850**
Cotton Seed	**0.915**	**0.850**
Corn	**0.926**	**0.850**
Wheat	**0.910**	**0.850**
Soybean	**0.917**	**0.850**

[a] At 5% significance level with 11 observations.
Bold characterizes failure to reject null hypothesis that sample is from normal distribution.

From Tables 3.7 it is evident that a significant number of yield data (17 out of 19) were coming from a normal population. However, from Table 3.7 it is clear that all the price series were following a normal distribution.

The unit of observation for yield data was the individual replication. Since there were four replications for each year, there were a total of maximum 44 observations for 11 year period. For consistency, normal distributions of prices were created containing 44 observations for each product on the basis of the following concept of normal distribution. Given $X_{11} \sim N(\mu, \sigma^2)$, and if $E(X_{11}) = \mu = E(X_{44})$, and $V(X_{11}) = \sigma^2 = V(X_{44})$, then $X_{44} \sim N(\mu, \sigma^2)$. Where X_{11} represents actual adjusted price data with 11 observations, X_{44} represents generated price data with 44 observations, N represents normal distribution, μ represents mean of the distribution, σ_2 represents variance of the distribution.

For the purpose of generating new price series with restricted maximum and minimum values, standard deviations from Table 3.5 and maximum and minimum values associated with 5 products were used through a random normal number generating process in SAS. The maximum and minimum values are restricted for generating new price series within the historical extremes for the specified 11 year period. Table 3.9 shows summary statistics associated with the generated price distributions.

Table 3.9: Summary Statistics Associated with Generated Prices.

PRODUCT	UNIT	MEAN	SD	CV(%)	RANGE
		$	$	$	$
Lint Cotton	$/lbs	0.64	0.05	8.61	0.22
Seed Cotton	$/ton	106.44	31.89	29.96	122.56
Corn	$/bu	2.96	0.52	17.83	2.03
Wheat	$/bu	3.48	0.35	10.27	1.21
Soybean	$/bu	6.94	0.75	10.84	3.00

From Table 3.9 it can be seen that the generated price distributions have means close to the desired means and are within the specified ranges. Standard deviations for the generated data were under estimated because the generated normal distributions were truncated within the specified maximum and minimum values. The coefficient of variations and ranges of all product prices were under estimated by 2.75 to 8.41%, and one cent to $22.87 respectively. It is apparent that the generated prices are comparatively less variable than the actual adjusted market price. Given the overall variability of detrended yields and generated prices the loss in variability of prices was considered negligible for the purpose of this study.

CHAPTER 4
GENERAL RESULTS AND ECONOMIC ANALYSIS

BUDGET ANALYSIS

The initial step in the analysis was to develop enterprise budgets for each of the states of nature represented in the data set. Yield and price data sets contained 44 observations representing 44 states of nature. Standard enterprise budgets for each of the 44 observations were prepared using the Mississippi State Budget Generator (MSBG) for the following soil/enterprise situations:

A. Commerce Silt Loam Soil
   1. Cotton
   2. Corn
   3. Soybean

B. Sharkey Clay Soil
   1. Soybean
   2. Soybean-Wheat Double Crop

Table 4.1 shows a sample base-line enterprise budget for cotton production. This base-line budget was adjusted to reflect differences in yields and associated costs and returns for each observation in cotton production. Research yield results were initially expressed in terms of seed cotton yield. These data were converted to lint and seed yield components using standardized conversion factors (Paxton). Enterprise budgets were customized to reflect cultural practices adopted in the Mississippi delta area specific to the Northeast Research Station study. Cotton was considered a program crop and a target price was set at 73 cents/lb for lint cotton. The farm was assumed to receive deficiency payments on 920 lbs of lint cotton, which is the payment yield for Tensas parish, the location of Northeast Research Station. Under the most recent farm bill, the payment yield was frozen at a fixed level and this is reflected in this analysis. A deficiency payment would be made only when the season average price fell below the target price. All input prices were held constant at 1993 levels. Input costs, except those associated with ginning and corn drying were fixed across all observations. Both ginning charges for cotton and charges for drying corn are a function of yield. Tables 4.2, 4.3, 4.4, and 4.5 show baseline enterprise budgets for corn, soybeans, and wheat-soybean double crop for the indicated soil types.

Net returns from individual crops were aggregated across each rotation to obtain net returns from each rotational pattern. Net returns per rotational acre were determined by multiplying the per acre budgets by the proportion of that crop in that rotation. For example, if there were three crops in the rotation, each crop budget would be multiplied by 0.333 and costs and returns summed over all three crops. The justification for this approach is that total acreage of each crop grown on the farm tends to remain relatively constant over time. The number of aggregated net returns that could be generated, were 44, 40, and 36 for continuous, two crop, and three crop schemes respectively. Inclusion of all three crops in a three year

Table 4.1: Summary of Estimated Costs and Returns Per Acre Continuous Cotton, Silt Loam Soil, 6-row Equipment, Solid Planted, Owner-operators, Mississippi Delta Area, Louisiana, 1993.

ITEM	UNIT	PRICE	QUANTITY	AMOUNT
		dollars		dollars
INCOME				
Cotton lint[a]	lbs	0.64	1109.5100	710.08
Cottonseed prod[b]	lb	0.05	1719.7400	85.99
Deficiency payment[c]	lbs	0.09	920.0000	82.80
Cotton checkoff	bale	2.26	-2.3100	-5.22

TOTAL INCOME				873.57
DIRECT EXPENSES				
CUSTOM	acre	11.00	1.0000	11.00
DEFOLIANT	acre	19.06	1.0000	19.06
FERTILIZER	acre	18.40	1.0000	18.40
FUNGICIDES	acre	14.20	1.0000	14.20
HERBICIDES	acre	25.43	1.0000	25.43
HIRED LABOR	acre	5.28	1.0000	5.28
INSECTICIDES	acre	89.50	1.0000	89.50
OTHER[d]	acre	69.81	1.0000	98.57
SEED	acre	9.24	1.0000	9.24
OPERATOR LABOR	hour	6.00	2.8882	17.33
OWNER LABOR	hour	10.00	0.8580	8.58
DIESEL FUEL	gal	0.76	19.4668	14.79
GASOLINE	gal	1.07	1.2750	1.36
REPAIR & MAINTENANCE	acre	51.12	1.0000	51.12
INTEREST ON OP. CAP.	acre	13.09	1.0000	13.09

TOTAL DIRECT EXPENSES				396.96
RETURNS ABOVE DIRECT EXPENSES				476.61
TOTAL FIXED EXPENSES				76.98

TOTAL SPECIFIED EXPENSES				473.94
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				399.63

[a] Yield and price are the means taken from Tables 3.2 and 3.9 respectively.
[b] Cotton seed is 1.55 (ratio obtained from A.E.A Information Series (Paxton)) times cotton lint.
[c] Price of 73 cents/lb is set for target price.
[d] Ginning charges of 8 cents/lb for cotton lint.

Table 4.2: Summary of Estimated Costs and Returns Per Acre Continuous Soybeans, Clay Soil, 8-row Equipment, (20 inch rows), Owner-operators, Mississippi Delta Area, Louisiana, 1993.

ITEM	UNIT	PRICE	QUANTITY	AMOUNT
		dollars		dollars
INCOME				
Soybean[a]	bu	6.94	45.4300	315.28
TOTAL INCOME				315.28
DIRECT EXPENSES				
CUSTOM	acre	1.00	1.0000	1.00
HERBICIDES	acre	32.14	1.0000	32.14
HIRED LABOR	acre	2.40	1.0000	2.40
INSECTICIDES	acre	2.65	1.0000	2.65
SEED	acre	13.50	1.0000	13.50
OPERATOR LABOR	hour	6.00	0.6980	4.19
OWNER LABOR	hour	10.00	0.2750	2.75
DIESEL FUEL	gal	0.76	4.7730	3.63
GASOLINE	gal	1.07	1.4000	1.50
REPAIR & MAINTENANCE	acre	18.18	1.0000	18.18
INTEREST ON OP. CAP.	acre	2.69	1.0000	2.69
TOTAL DIRECT EXPENSES				84.62
RETURNS ABOVE DIRECT EXPENSES				230.66
TOTAL FIXED EXPENSES				26.77
TOTAL SPECIFIED EXPENSES				111.39
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				203.89

[a] Yield and price are the means taken from Tables 3.2 and 3.9 respectively.

Table 4.3: Summary of Estimated Costs and Returns Per Acre Continuous Corn, Silt Loam Soil, 8-row Equipment, (38 inch rows), Owner-operators, Mississippi Delta Area, Louisiana, 1993.

ITEM	UNIT	PRICE	QUANTITY	AMOUNT
		dollars		dollars
INCOME				
Corn[a]	bu	2.96	134.8600	399.19
TOTAL INCOME				399.19
DIRECT EXPENSES				
CUSTOM(drying charge)	bu	0.19	134.8600	25.62
FERTILIZER	acre	41.40	1.0000	41.40
HERBICIDES	acre	33.76	1.0000	33.76
HIRED LABOR	acre	3.12	1.0000	3.12
INSECTICIDES	acre	12.25	1.0000	12.25
SEED	acre	26.68	1.0000	26.68
OPERATOR LABOR	hour	6.00	1.4010	8.41
OWNER LABOR	hour	10.00	0.2750	2.75
DIESEL FUEL	gal	0.76	8.5150	6.47
GASOLINE	gal	1.07	2.0000	2.14
REPAIR & MAINTENANCE	acre	23.82	1.0000	23.82
INTEREST ON OP. CAP.	acre	7.17	1.0000	7.17
TOTAL DIRECT EXPENSES				193.59
RETURNS ABOVE DIRECT EXPENSES				205.60
TOTAL FIXED EXPENSES				35.72
TOTAL SPECIFIED EXPENSES				222.69
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				169.88

[a] Yield and price are the means taken from Tables 3.2 and 3.9 respectively.

Table 4.4: Summary of Estimated Costs and Returns Per Acre Wheat and Soybeans, (double crop), Clay Soil, 8-row Equipment, Owner-operators, Mississippi Delta area, Louisiana, 1993.

ITEM	UNIT	PRICE	QUANTITY	AMOUNT
		dollars		dollars
INCOME				
Wheat[a]	bu	3.48	34.1000	118.67
Soybean[a]	bu	6.94	30.3300	210.49

TOTAL INCOME				329.16
DIRECT EXPENSES				
CUSTOM	acre	1.00	1.0000	1.00
FERTILIZER	acre	10.35	1.0000	10.35
HERBICIDES	acre	32.14	1.0000	32.14
HIRED LABOR	acre	4.08	1.0000	4.08
INSECTICIDES	acre	2.65	1.0000	2.65
SEED	acre	26.10	1.0000	26.10
OPERATOR LABOR	hour	6.00	1.3080	7.85
OWNER LABOR	hour	10.00	0.5500	5.50
DIESEL FUEL	gal	0.76	8.3410	6.34
GASOLINE	gal	1.07	2.8000	3.00
REPAIR & MAINTENANCE	acre	35.51	1.0000	35.51
INTEREST ON OP. CAP.	acre	6.23	1.0000	6.23

TOTAL DIRECT EXPENSES				140.74
RETURNS ABOVE DIRECT EXPENSES				188.42
TOTAL FIXED EXPENSES				46.62

TOTAL SPECIFIED EXPENSES				187.37
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				141.80

[a] Yields and prices are the means taken from Tables 3.2 and 3.9 respectively

Table 4.5: Summary of Estimated Costs and Returns Per Acre Soybeans, Silt Loam Soil, 8-row Equipment, (20 inch rows), Owner-operators, Mississippi Delta Area, Louisiana, 1993.

ITEM	UNIT	PRICE	QUANTITY	AMOUNT
		dollars		dollars
INCOME				
Soybean	bu	6.94	33.9700	235.75

TOTAL INCOME				235.75
DIRECT EXPENSES				
CUSTOM	acre	1.00	1.0000	1.00
HERBICIDES	acre	32.14	1.0000	32.14
HIRED LABOR	acre	2.40	1.0000	2.40
INSECTICIDES	acre	2.65	1.0000	2.65
SEED	acre	13.50	1.0000	13.50
OPERATOR LABOR	hour	6.00	0.8630	5.18
OWNER LABOR	hour	10.00	0.2750	2.75
DIESEL FUEL	gal	0.76	6.4430	4.90
GASOLINE	gal	1.07	1.4000	1.50
REPAIR & MAINTENANCE	acre	19.91	1.0000	19.91
INTEREST ON OP. CAP.	acre	4.32	1.0000	4.32

TOTAL DIRECT EXPENSES				90.24
RETURNS ABOVE DIRECT EXPENSES				145.51
TOTAL FIXED EXPENSES				29.34

TOTAL SPECIFIED EXPENSES				119.58
RETURNS ABOVE TOTAL SPECIFIED EXPENSES				116.17

[a] Yield and price are the means taken from Tables 3.2 and 3.9 respectively.

rotation system required the deletion of last eight aggregated net returns for continuous schemes and last four aggregated net returns for two crop rotations. This resulted in 36 observations in each distribution of aggregated net returns. Table 4.6 shows the summary statistics associated with the 11 crop rotational schemes.

Table 4.6: Average Net Returns per Rotational Acre, Northeast Research Station, Louisiana, 1983-93.

ROTATION[a]	MEAN	SD	CV(%)	MAX.	MIN.	W STATISTIC
	$	$		$	$	
CSL1	498.01	215.15	43.20	949.80	-3.38	0.985
CSL2	225.20	78.34	34.79	335.69	38.56	0.930[b]
CSL3	214.39	87.55	40.84	434.17	74.08	0.929[b]
CSL4	411.20	109.92	26.73	686.86	236.96	0.946
CSL5	268.67	43.77	16.29	371.06	183.44	0.974
CSL6	439.81	118.49	26.94	600.56	193.23	0.893[b]
CSL7	299.07	51.52	17.23	386.52	172.45	0.944
CSL8	393.73	62.19	15.79	502.06	231.54	0.916[b]
CSL9	392.17	62.47	15.93	488.49	267.08	0.949
SC10	153.41	57.22	37.30	265.72	29.27	0.975
SC11	205.19	95.13	46.36	457.42	30.95	0.969

[a] Each rotation is identified in Table 3.1
[b] Indicates nonnormality at 5% significance level, critical value being 0.935 with 36 observations.

As shown in Table 4.6, continuous cotton (CSL1) has the highest mean net return. However, it is not obvious that this rotation is superior to other rotations because the variability of returns is also very high. In addition, this rotation is the only rotation with a negative minimum income level. Continuous soybean (CSL2) and corn (CSL3) are inferior to other rotations on silt loam soil because their means are lower and coefficients of variation are higher than those of other rotations on silt loam. However, continuous soybean (CSL2) on silt loam soil is superior to continuous soybean(SC10) on sharkey clay as CSL2 generates higher average net return with a lower coefficient of variation. Both crop schemes (SC10 & SC11) on sharkey clay soil generate lower net returns than any scheme on silt loam soil.

From the W statistics shown in Table 4.6, it is apparent that net returns from four schemes do not follow a normal distribution at the 5% significance level. It has been argued that a MOTAD or Target MOTAD type of approach is more appealing than mean variance if distributions are skewed (Thomson and Hazell).

In the above analysis of net returns cotton was considered to be program crop. A deficiency payment for cotton was made when the generated lint cotton price fell under the target price set at 73 cents/lb. Because of the uncertainty surrounding farm programs, it is important to examine the alternative rotational patterns in the absence of government program. The existing farm bill is scheduled to expire at the end of 1995. Proposals under discussion at this time generally focus on some sort of "decoupling" provisions. This means that payments made by the government to producers would be "decoupled" or not related to current production. Therefore, the rotational patterns were evaluated without government program benefits. Only net returns from rotational schemes involving cotton were affected because other crops were assumed to be produced outside the government program provisions. Table 4.7 shows the summary statistics associated with net returns without deficiency payment.

Table 4.7: Average Net Returns without Deficiency Payment per Rotational Acre, Northeast Research Station, Louisiana, 1983-93.

ROTATION[a]	MEAN	SD	CV(%)	MAX.	MIN.	W STATISTIC
	$	$		$	$	
CSL1	412.42	228.07	55.30	920.64	-164.47	0.987
CSL4	364.10	120.34	33.02	668.19	181.59	0.932[b]
CSL6	401.93	124.93	31.08	553.50	112.69	0.907[b]
CSL7	267.72	57.57	21.50	357.88	118.76	0.939
CSL8	330.97	76.20	23.02	468.51	124.48	0.912[b]
CSL9	332.56	66.72	20.06	452.82	178.23	0.974

[a] Each rotation is identified in Table 3.1
[b] Indicates nonnormality at 5% significance level, critical value being 0.935 with 36 observations.

As shown in Table 4.7 mean net returns are lower without deficiency payments. The standard deviations and coefficient of variations, both have increased. Both the maximum and minimum values have decreased. The distribution pattern didn't change except CSL4 which became normally distributed without deficiency payments. These results are as expected since the deficiency payment reduces variability in product prices.

REPRESENTATIVE FARM

A representative farm model was developed following McCraney for the evaluation of alternative crop rotational schemes adopted by the farm. This model is presented in Table 4.8. The upper limits for available land were obtained from the representative farm included in Projected Costs and Returns and Cash Flows for Major Agricultural Enterprises Louisiana, 1993 published by Department of

Table 4.8: Representative Farm Model, Mississippi Delta Area, 1993.

Land Acreage	
Commerce Silt Loam	480
Sharkey Clay Soil	740
Total	1,220
Investment ($)	
Land ($)	1,033,076
Machinery ($)	230,113
Total ($)	1,263,189
Target Income ($)	
Family Living ($)	24,929
Cash Overhead Expense ($)	36,870
Land Principal ($)	20,662
Machinery Principal ($)	18,356
Interest on debt ($)	29,839
Total ($)	130,655

Agricultural Economics and Agribusiness, (Vandeveer). The farm was assumed to include 1,220 acres with 480 acres of commerce silt loam soil and 740 acres of sharkey clay soil. This proportional representation of acreage under two soil types (1:1.54) is in general agreement with the overall distribution of these two soil types in northeast Louisiana (1:1.71) (Schumacher et al.). Total investment in land is $1,033,076.

Land investment was based on per acre values of silt and clay lands at $975 and $650 respectively after adjustments for increase in average value of land reported by USDA. Investment in machinery was estimated at $230,113. The target income level shown in Table 4.7 represents the income level needed by the farm to meet all of its financial commitments. The farm was assumed to finance 40% of the investments through debt acquired at a 10% interest rate. Principal payments on both land and machinery were estimated assuming constant payments of $20,662 for land for 20 years and $18,356 for machinery for 5 years. The amounts for family living and cash overhead expense taken from McCraney were revised on the basis of change in consumer price index(CPI) and producer price index(PPI) respectively.

TARGET MOTAD LINEAR PROGRAMMING FORMULATION

A Target MOTAD model was used to evaluate the distribution of returns from the alternative rotations within a whole farm concept. A description of the model and the underlying assumptions were presented earlier. A sample Target MOTAD tableau is given in Table 4.9.

There were 46 variables out of which 11 variables represent different rotational schemes which are CSL1 to CSL9 and SC10, SC11. The remaining 36 variables z1 to z36 represent 36 negative deviations of income below target income under 36 states of nature.

The first row is the objective function for the Target MOTAD model. The coefficients of CSL1 to SC11 are mean net returns for each rotation. The coefficients of z1 to z36 are zeros.

The 36 (1 to 36) constraints signifying 36 states of nature are represented by next 36 rows. The coefficients of decision variables CSL1 to SC11 are assigned the respective

Table 4.9: Target MOTAD Model for Portfolio Containing All Rotations[a], Minimum Target Income Required is $120,000, Relative Risk Measure (G) is 0.

MAX 498.02 CSL1 + 225.20 CSL2 + 214.39 CSL3 + 411.20 CSL4
+ 268.67 CSL5 + 439.81 CSL6 + 299.06 CSL7 + 393.73 CSL8 +
392.17 CSL9 + 153.41 SC10 + 205.19 SC11
SUBJECT TO
1) 670.65 CSL1 + 162.94 CSL2 + 218.93 CSL3 + 368.27 CSL4
+ 211.72 CSL5 + 480.21 CSL6 + 273.23 CSL7 + 369.27 CSL8 +
186.69 CSL9 + 107.54 SC10 + 206.71 SC11 + Z1 ≥ 120,000.00
2) 422.46 CSL1 + 226.72 CSL2 + 185.73 CSL3 + 457.78 CSL4
+ 301.27 CSL5 + 575.58 CSL6 + 313.71 CSL7 + 376.71 CSL8 +
287.60 CSL9 + 132.04 SC10 + 106.94 SC11 + Z2 ≥ 120,000.00
3) 539.41 CSL1 + 262.12 CSL2 + 96.63 CSL3 + 440.71 CSL4
+ 256.88 CSL5 + 562.83 CSL6 + 293.75 CSL7 + 379.98 CSL8 +
337.76 CSL9 + 184.49 SC10 + 240.94 SC11 + Z3 ≥ 120,000.00
4) 461.09 CSL1 + 165.31 CSL2 + 203.94 CSL3 + 472.75 CSL4
+ 252.15 CSL5 + 576.83 CSL6 + 316.01 CSL7 + 502.06 CSL8 +
365.12 CSL9 + 213.82 SC10 + 224.55 SC11 + Z4 ≥ 120,000.00
5) 674.35 CSL1 + 232.44 CSL2 + 182.91 CSL3 + 264.29 CSL4
+ 240.17 CSL5 + 491.17 CSL6 + 283.61 CSL7 + 377.68 CSL8 +
461.76 CSL9 + 92.72 SC10 + 273.37 SC11 + Z5 ≥ 120,000.00
6) 712.73 CSL1 + 274.34 CSL2 + 252.03 CSL3 + 236.96 CSL4
+ 266.32 CSL5 + 562.69 CSL6 + 352.20 CSL7 + 388.73 CSL8 +
450.64 CSL9 + 146.11 SC10 + 215.95 SC11 + Z6 ≥ 120,000.00
7) 834.34 CSL1 + 309.33 CSL2 + 188.19 CSL3 + 308.85 CSL4
+ 227.35 CSL5 + 521.06 CSL6 + 342.71 CSL7 + 373.48 CSL8 +
422.01 CSL9 + 151.95 SC10 + 156.74 SC11 + Z7 ≥ 120,000.00
8) 496.37 CSL1 + 198.63 CSL2 + 233.31 CSL3 + 353.69 CSL4
+ 282.95 CSL5 + 577.37 CSL6 + 308.79 CSL7 + 442.95 CSL8 +
371.34 CSL9 + 182.32 SC10 + 257.21 SC11 + Z8 ≥ 120,000.00
9) 230.76 CSL1 + 217.81 CSL2 + 217.81 CSL3 + 244.95 CSL4
+ 268.53 CSL5 + 410.06 CSL6 + 312.95 CSL7 + 397.28 CSL8 +
488.49 CSL9 + 116.36 SC10 + 84.43 SC11 + Z9 ≥ 120,000.00
10) 232.61 CSL1 + 253.45 CSL2 + 246.43 CSL3 + 340.14 CSL4
+ 294.07 CSL5 + 481.74 CSL6 + 336.49 CSL7 + 375.46 CSL8 +
478.70 CSL9 + 151.12 SC10 + 137.25 SC11 + Z10 ≥ 120,000.00
11) 363.87 CSL1 + 49.03 CSL2 + 134.87 CSL3 + 282.03 CSL4
+ 252.97 CSL5 + 337.90 CSL6 + 333.57 CSL7 + 342.67 CSL8 +
401.88 CSL9 + 133.21 SC10 + 96.29 SC11 + Z11 ≥ 120,000.00
12) 184.62 CSL1 + 301.79 CSL2 + 358.43 CSL3 + 365.26 CSL4
+ 302.46 CSL5 + 506.87 CSL6 + 274.02 CSL7 + 416.13 CSL8 +
409.16 CSL9 + 265.72 SC10 + 217.06 SC11 + Z12 ≥ 120,000.00
13) 634.90 CSL1 + 239.25 CSL2 + 196.53 CSL3 + 579.76 CSL4
+ 299.81 CSL5 + 441.62 CSL6 + 347.48 CSL7 + 386.20 CSL8 +
484.29 CSL9 + 132.89 SC10 + 159.73 SC11 + Z13 ≥ 120,000.00
14) 564.43 CSL1 + 325.77 CSL2 + 161.03 CSL3 + 686.86 CSL4
+ 355.20 CSL5 + 515.37 CSL6 + 286.03 CSL7 + 417.27 CSL8 +
446.94 CSL9 + 143.80 SC10 + 202.54 SC11 + Z14 ≥ 120,000.00

(table con'd)

15) 473.42 CSL1 + 333.31 CSL2 + 186.99 CSL3 + 546.90 CSL4
+ 274.31 CSL5 + 404.75 CSL6 + 357.87 CSL7 + 363.29 CSL8 +
304.34 CSL9 + 180.95 SC10 + 210.79 SC11 + Z15 ≥ 120,000.00
16) 424.53 CSL1 + 49.03 CSL2 + 121.90 CSL3 + 594.98 CSL4
+ 296.58 CSL5 + 479.25 CSL6 + 172.45 CSL7 + 258.06 CSL8 +
352.14 CSL9 + 94.23 SC10 + 181.99 SC11 + Z16 ≥ 120,000.00
17) 949.80 CSL1 + 270.17 CSL2 + 434.17 CSL3 + 502.83 CSL4
+ 293.83 CSL5 + 273.08 CSL6 + 344.13 CSL7 + 359.07 CSL8 +
419.62 CSL9 + 44.89 SC10 + 243.06 SC11 + Z17 ≥ 120,000.00
18) 789.12 CSL1 + 306.72 CSL2 + 422.35 CSL3 + 572.55 CSL4
+ 220.25 CSL5 + 292.35 CSL6 + 230.24 CSL7 + 404.74 CSL8 +
345.36 CSL9 + 187.84 SC10 + 263.27 SC11 + Z18 ≥ 120,000.00
19) 714.26 CSL1 + 226.05 CSL2 + 256.11 CSL3 + 534.15 CSL4
+ 294.97 CSL5 + 287.11 CSL6 + 342.91 CSL7 + 362.32 CSL8 +
267.08 CSL9 + 163.17 SC10 + 251.57 SC11 + Z19 ≥ 120,000.00
20) 756.13 CSL1 + 143.25 CSL2 + 298.67 CSL3 + 610.73 CSL4
+ 223.69 CSL5 + 211.12 CSL6 + 189.81 CSL7 + 231.54 CSL8 +
313.09 CSL9 + 212.74 SC10 + 259.48 SC11 + Z20 ≥ 120,000.00
21) 324.21 CSL1 + 272.40 CSL2 + 86.55 CSL3 + 270.32 CSL4
+ 199.96 CSL5 + 249.16 CSL6 + 305.77 CSL7 + 331.22 CSL8 +
390.11 CSL9 + 86.12 SC10 + 190.02 SC11 + Z21 ≥ 120,000.00
22) 248.92 CSL1 + 306.55 CSL2 + 169.90 CSL3 + 352.98 CSL4
+ 275.36 CSL5 + 278.86 CSL6 + 234.02 CSL7 + 403.71 CSL8 +
330.25 CSL9 + 217.01 SC10 + 222.043SC11 + Z22 ≥ 120,000.00
23) 199.47 CSL1 + 322.50 CSL2 + 248.33 CSL3 + 368.82 CSL4
+ 228.36 CSL5 + 238.62 CSL6 + 342.35 CSL7 + 373.96 CSL8 +
272.66 CSL9 + 226.08 SC10 + 315.70 SC11 + Z23 ≥ 120,000.00
24) -3.38 CSL1 + 251.63 CSL2 + 243.98 CSL3 + 360.33 CSL4
+ 189.69 CSL5 + 193.23 CSL6 + 210.12 CSL7 + 237.88 CSL8 +
285.47 CSL9 + 200.18 SC10 + 214.97 SC11 + Z24 ≥ 120,000.00
25) 424.90 CSL1 + 163.07 CSL2 + 112.83 CSL3 + 409.05 CSL4
+ 311.63 CSL5 + 487.63 CSL6 + 307.25 CSL7 + 416.11 CSL8 +
429.68 CSL9 + 123.02 SC10 + 30.96 SC11 + Z25 ≥ 120,000.00
26) 425.40 CSL1 + 186.98 CSL2 + 151.51 CSL3 + 401.79 CSL4
+ 343.05 CSL5 + 553.14 CSL6 + 297.21 CSL7 + 471.57 CSL8 +
411.47 CSL9 + 144.21 SC10 + 32.68 SC11 + Z26 ≥ 120,000.00
27) 332.99 CSL1 + 202.13 CSL2 + 239.43 CSL3 + 367.46 CSL4
+ 257.94 CSL5 + 505.97 CSL6 + 299.99 CSL7 + 477.63 CSL8 +
434.79 CSL9 + 120.54 SC10 + 59.09 SC11 + Z27 ≥ 120,000.00
28) 223.15 CSL1 + 38.56 CSL2 + 141.71 CSL3 + 333.16 CSL4
+ 183.44 CSL5 + 494.70 CSL6 + 274.53 CSL7 + 387.91 CSL8 +
427.21 CSL9 + 29.27 SC10 + 116.97 SC11 + Z28 ≥ 120,000.00
29) 590.17 CSL1 + 180.67 CSL2 + 390.03 CSL3 + 408.38 CSL4
+ 301.66 CSL5 + 506.74 CSL6 + 303.15 CSL7 + 414.40 CSL8 +
397.19 CSL9 + 105.56 SC10 + 122.50 SC11 + Z29 ≥ 120,000.00
30) 789.17 CSL1 + 203.78 CSL2 + 314.33 CSL3 + 418.64 CSL4
+ 277.38 CSL5 + 335.75 CSL6 + 386.52 CSL7 + 474.42 CSL8 +
424.21 CSL9 + 116.17 SC10 + 137.04 SC11 + Z30 ≥ 120,000.00

(table con'd)

31) 715.58 CSL1 + 279.66 CSL2 + 222.35 CSL3 + 377.46 CSL4 + 300.65 CSL5 + 600.56 CSL6 + 231.74 CSL7 + 422.38 CSL8 + 397.07 CSL9 + 89.57 SC10 + 165.77 SC11 + Z31 ≥ 120,000.00
32) 583.50 CSL1 + 178.31 CSL2 + 196.09 CSL3 + 367.16 CSL4 + 268.49 CSL5 + 524.64 CSL6 + 325.98 CSL7 + 466.96 CSL8 + 457.59 CSL9 + 109.10 SC10 + 139.66 SC11 + Z32 ≥ 120,000.00
33) 468.06 CSL1 + 264.57 CSL2 + 167.75 CSL3 + 312.23 CSL4 + 229.52 CSL5 + 389.90 CSL6 + 304.63 CSL7 + 420.22 CSL8 + 376.66 CSL9 + 258.74 SC10 + 384.14 SC11 + Z33 ≥ 120,000.00
34) 516.64 CSL1 + 127.46 CSL2 + 161.97 CSL3 + 450.50 CSL4 + 279.66 CSL5 + 358.49 CSL6 + 385.41 CSL7 + 466.86 CSL8 + 378.75 CSL9 + 175.67 SC10 + 319.87 SC11 + Z34 ≥ 120,000.00
35) 533.38 CSL1 + 335.69 CSL2 + 74.08 CSL3 + 336.99 CSL4 + 239.05 CSL5 + 440.19 CSL6 + 227.56 CSL7 + 416.72 CSL8 + 469.01 CSL9 + 256.23 SC10 + 457.42 SC11 + Z35 ≥ 120,000.00
36) 426.41 CSL1 + 245.72 CSL2 + 173.07 CSL3 + 474.97 CSL4 + 371.06 CSL5 + 505.36 CSL6 + 318.84 CSL7 + 467.31 CSL8 + 450.20 CSL9 + 216.42 SC10 + 387.77 SC11 + Z36 ≥ 120,000.00
37) CSL1 + CSL2 + CSL3 + CSL4 + CSL5 + CSL6 + CSL7 + CSL8 + CSL9 ≤ 480
38) SC10 + SC11 ≤ 740
39) 0.028 Z1 + 0.028 Z2 + 0.028 Z3 + 0.028 Z4 + 0.028 Z5 + 0.028 Z6 + 0.028 Z7 + 0.028 Z8 + 0.028 Z9 + 0.028 Z10 + 0.028 Z11 + 0.028 Z12 + 0.028 Z13 + 0.028 Z14 + 0.028 Z15 + 0.028 Z16 + 0.028 Z17 + 0.028 Z18 + 0.028 Z19 + 0.028 Z20 + 0.028 Z21 + 0.028 Z22 + 0.028 Z23 + 0.028 Z24 + 0.028 Z25 + 0.028 Z26 + 0.028 Z27 + 0.028 Z28 + 0.028 Z29 + 0.028 Z30 + 0.028 Z31 + 0.028 Z32 + 0.028 Z33 + 0.028 Z34 + 0.028 Z35 + 0.028 Z36 = 0
40) 0.95 CSL3 + 0.475 CSL4 + 0.475 CSL5 + 0.317 CSL7 + 0.317 CSL9 ≤ 470.25
41) 2.18 CSL1 + 1.09 CSL4 + 1.09 CSL6 + 0.727 CSL7 + 1.453 CSL8 + 1.453 CSL9 ≤ 480
42) 0.86 CSL1 + 0.835 CSL2 + 0.43 CSL4 0.42 CSL5 + 0.848 CSL6 + 0.565 CSL7 + 0.852 CSL8 + 0.570 CSL9 ≤ 424.37
43) 0.98 SC11 ≤ 480.00
44) 0.07 SC10 ≤ 424.37
45) 0.3 CSL1 + 0.42 CSL2 + 0.08 CSL3 + 0.19 CSL4 + 0.25 CSL5 + 0.36 CSL6 + 0.27 CSL7 + 0.34 CSL8 + 0.23 CSL9 ≤ 327.25
46) 0.34 SC10 + 0.835 SC11 ≤ 294.25

[a] Rotations are defined in Table 3.1

net returns obtained in that state of nature. The coefficients of z's are assigned 1 if it corresponds to the state of nature, 0 otherwise. The target income is fixed at 130,655 dollars.

The two constraints (37 and 38) represent land available for each soil type: silt and clay. The upper limits for available land were obtained from the representative farm as described earlier.

The risk constraint is represented by constraint 39. As there are 36 states of nature, the probability, being equal across each state, is 1/36 i.e. 0.028. The risk constant G is parameterized from 0 to the maximum possible.

Labor constraints (40 to 46) represent labor availability for four months May, August, September, and October for both silt and clay lands. The coefficients were calculated from estimations of monthly income and expense flows per acre for the enterprise budgets used in the analysis. These four months were selected because they represent critical time periods for labor availability. Upper limits for available labor hours were taken from Denison. For purposes of this analysis, a total 2.5 units of labor were assumed to be available.

ECONOMIC ANALYSIS

Target MOTAD was used to determine the expected income maximizing crop rotations from the possible set of rotations on each soil type. Solutions of the Target MOTAD analysis are second degree stochastic dominant to solutions provided by MOTAD. The risk parameter G in the Target MOTAD model is measured in terms of expected value of the negative deviations below target income. At G=0 no negative income deviations are allowed in any state. At G>0 the decision maker is willing to take some risk of having income below target level. A risk return frontier can be developed by tracing out the expected income versus corresponding risk level. In the original model, cotton was considered a program crop and deficiency payments were considered in the revenue stream when the generated lint cotton price fell under the target price of $0.73/lb. An identical model was considered that did not include deficiency payments in the revenue stream. In addition, another Target MOTAD model was developed considering only the continuous crops.

Results of the Target MOTAD analysis when the decision maker is considering all available cropping schemes in his/her portfolio are presented in the Table 4.10. Two sets of solutions were obtained corresponding two scenarios: with and with out deficiency payment. The variance of income (V) for each farm plan was estimated using (Elton and Gruber): $V = \Sigma_j x_j^2 \sigma_j^2$ where σ_j^2 and x_j represent the net return variance and solution value of enterprise j respectively.

In the first scenario (with deficiency payments), initially the level of risk (G) was set at 0 i.e. no risk. With G at 0, a feasible solution was obtained with an expected income of $325,465.02 (including deficiency

Table 4.10: Target MOTAD Results for Portfolio Containing All Rotational and Continuous Schemes with and without Deficiency Payment[a].

Item		With Deficiency Payment	Without Deficiency Payment
Expected Income ($)		325,465.02	300,116.08
Variance (Millions)		7,448.01	4,238.20
Risk Measure (G)		0.00	0.00
COV[b] (%)		26.52	21.69
Target Income($)		130,655.00	130,655.00
Rotations[c]		------------Acres----------	
CSL1		366.41	0.00
CSL2		0.00	0.00
CSL3		0.00	0.00
CSL4		0.00	0.00
CSL5		113.58	39.63
CSL6		0.00	440.37
CSL7		0.00	0.00
CSL8		0.00	0.00
CSL9		0.00	0.00
SC10		574.85	574.85
SC11		118.32	118.32
Resources Available[d]		---Resource Utilization---	
Land:CSL in Acres	(480.00)	480.00	480.00
Land:SC in Acres	(740.00)	693.17	693.17
Labor hours:May:CSL	(327.25)	138.88	168.63
Labor hours:Aug:CSL	(470.25)	372.73	18.83
Labor hours:Sep:CSL	(480.00)	480.00	480.00
Labor hours:Oct:CSL	(424.37)	362.83	389.86
Labor hours:May:SC	(294.25)	294.25	294.25
Labor hours:Aug:SC	(470.25)	0.00	0.00
Labor hours:Sep:SC	(480.00)	480.00	480.00
Labor hours:Oct:SC	(424.37)	115.95	115.95

[a] Deficiency payment for cotton was considered at the target price set at 73 cents/lb for lint cotton.
[b] Coefficient of Variation.
[c] Rotations are defined in Table 3.1
[d] Available quantities for each resource are presented in parenthesis.

payments). At this level only CSL1 (continuous cotton) with 366.41 acres, and CSL5 (corn-soybean) with 113.58 acres on silt soils came into the solution. The major part (76.33%) of available silt land (480 acres) was used by CSL1. In the second scenario (without a deficiency payment) the initial feasible solution, at zero risk level, was obtained with an expected income of $300,116.08, a decrease of $25,348.94 from the first scenario. At this level, CSL1 was dropped from the solution and CSL6 (cotton-soybean), with 440.37 acres, came into the solution. The level of CSL5 in the solution decreased considerably from 113.58 acres to 39.63 acres. In this scenario, the major part (91.74%) of available silt land (480 acres) was used by CSL6. The solution levels at zero risk levels under both scenarios remained stable i.e. the increasing risk levels with higher positive values did not change the solution patterns.

Apart from continuous cotton (CSL1), the overall selection of rotational patterns for silty soil at the zero risk level was limited to only two year rotations. The solution pattern for clay land remained unchanged under both scenarios. Both schemes on clay soil SC10 (continuous soybean) and SC11 (wheat-soybean double crop) came into the solutions with 574.85 acres and 118.32 respectively. The major part (82.93%) of utilized clay land (693.17 acres) was used by SC10. Variability in expected income, represented by the coefficient of variation(COV) decreased from 26.52% in the first scenario to 21.69% in the second scenario.

From the resource utilization pattern presented in Table 4.10 it is apparent that available silt land was fully utilized but the available clay land was under utilized for both scenarios. The pattern remained the same under both scenarios. Out of the available amount of labor hours for the two soils during four months, only labor hours in september and october for silt soils and labor hours in september for clay soils were fully utilized under both the scenarios. However, under the first scenario (with deficiency payment) considerable under utilization of labor hours were found in the months of May (silt soil), August (clay soil), October (clay soil). Under the first scenario, the overall resource utilization pattern was higher for silty soil than the pattern for the clay soil. The resource utilization pattern under both scenarios were similar except for a decrease in utilization of labor hours in May (silt soil) and August (silt soil), but an increase in utilization of labor hours in October (silt soil).

Results of the Target MOTAD analysis when the decision maker is considering only continuous cropping schemes on silt soil and both schemes on clay soil in the portfolio are presented in the Table 4.11. Two sets of solutions were obtained corresponding to two scenarios: with and with out deficiency payment.

Table 4.11: Target MOTAD Results for Portfolio Containing Only Continuous Schemes with and without Deficiency Payment[a].

Item		With Deficiency Payment	Without Deficiency Payment
Expected Income ($)		311,204.42	279,341.64
Variance (Millions)		7,251.15	6,504.76
Risk Measure (G)		0.00	0.00
COV[b] (%)		27.36	28.87
Target Income($)		130,655.00	130,655.00
Rotations[c]		Acres	
CSL1		366.41	313.95
CSL2		0.00	166.04
CSL3		113.58	0.00
CSL4		0.00	0.00
CSL5		0.00	0.00
CSL6		0.00	0.00
CSL7		0.00	0.00
CSL8		0.00	0.00
CSL9		0.00	0.00
SC10		458.97	574.85
SC11		165.51	118.32
Resources Available[d]		Resource Utilization	
Land:CSL in Acres	(480.00)	480.00	480.00
Land:SC in Acres	(740.00)	624.48	693.17
Labor hours:May:CSL	(327.25)	120.15	163.92
Labor hours:Aug:CSL	(470.25)	426.68	273.14
Labor hours:Sep:CSL	(480.00)	480.00	411.28
Labor hours:Oct:CSL	(424.37)	315.15	408.65
Labor hours:May:SC	(294.25)	294.25	294.25
Labor hours:Aug:SC	(470.25)	0.00	0.00
Labor hours:Sep:SC	(480.00)	383.24	480.00
Labor hours:Oct:SC	(424.37)	162.19	163.93

[a] Deficiency payment for cotton was considered at the target price set at 73 cents/lb for lint cotton.
[b] Coefficient of Variation.
[c] Rotations are defined in Table 3.1
[d] Available quantities for each resource are presented in parenthesis.

In the first scenario (with deficiency payments), initially the level of risk (G) was set at 0, i.e. no risk. With G at 0, a feasible solution was obtained with an expected income of $311,204.42 (including deficiency payment). At this level only CSL1 (continuous cotton) with 366.41 acres, and CSL3 (continuous corn) with 113.58 acres on silt soils came into the solution. The major part (76.33%) of available silt land (480 acres) was used by CSL1. In the second scenario (without a deficiency payment) the initial feasible solution, at the zero risk level, was obtained with an expected income of $279,34.64, a decrease of $31,862.78 from the first scenario. At this level, CSL3 was deleted from the solution and CSL2 (continuous soybean) with 166.04 acres came into the solution. The solution level of CSL1 decreased from 366.41 acres to 313.95 acres. In this scenario the major part (65.31%) of available silt land (480 acres) was used by CSL1. The solution levels, at zero risk levels, under both scenarios remained stable i.e. the increasing risk levels with higher positive values did not change the solution patterns. Under the first scenario both schemes on clay soil SC10 (continuous soybean) and SC11 (wheat-soybean double crop) came into the solutions with 458.97 acres and 165.51 acres respectively.

The major part (73.49%) of utilized clay land (624.48 acres) was used by SC10. Under the second scenario, both schemes on clay soil SC10 (continuous soybean) and SC11 (wheat-soybean double crop) came into the solutions with 574.85 acres and 118.32 respectively. The major part (82.93%) of utilized clay land (693.17 acres) was used by SC10. The variability in the expected income, represented by coefficient of variation(COV) was increased from 27.36% in the first scenario to 28.87% in the second scenario.

From the resource utilization pattern presented in Table 4.11 it is apparent that available silt land was fully utilized but the available clay land was under utilized under both scenarios. Under the first scenario, 624.48 acres of clay land was utilized but, under the second scenario, utilization of clay land increased to 693.17 acres. Out of the available amount of labor hours for two soils during four months, only labor hours in May (clay soil) was fully utilized under both the scenarios. Under the first scenario (with deficiency payments) labor hours in August (silt soil) was fully utilized. However, considerable under utilization of labor hours were found in the months of May (silt soil), August (clay soil), October (clay soil). Under the first scenario, overall resource utilization pattern was higher for silt soil than the pattern for clay soil. The resource utilization pattern under both scenarios were similar for silt land (480 acres) and labor hours for silt soil in May (294.25 hours), labor hours for clay soil in August (0 hours). All the labor resources were increasingly utilized except August (silt soil), and September (silt soil).

Comparison of Table 4.10 and 4.11 revealed that expected income with the portfolio containing all schemes were much higher than the expected income with the portfolio containing only continuous schemes. Higher expected income could be obtained with deficiency payments for both portfolios. The coefficients of variability of expected incomes were all in the 20's. Continuous cotton came into all solutions except for the portfolio containing all schemes under the scenario of "without deficiency payment." The solution patterns for clay soil were similar except the solution for the portfolio containing only continuous schemes under the scenario of "with deficiency payment." The silt land was fully utilized in all solutions. Clay land was under utilized at the same level (693.17 acres) except for the solution in the portfolio containing continuous schemes with a deficiency payment where utilization further decreased to 624.48 acres. Under the scenario with deficiency payments, the second portfolio utilized more labor hours in August (silt soil), October (clay soil), less labor hours in May (silt soil), September (clay soil), October (silt soil), and both portfolios had similar utilization patterns for clay soil in the months of May(100%), and August(0%). Under the scenario without a deficiency payment, the second portfolio utilized more labor hours in August (silt soil), October (both soils), less labor hours in May (silt soil), September (silt soil), October (silt soil), and both portfolio had similar utilization pattern for clay soil in the months of May(100%), August(0%), September(100%). The solutions for both portfolios under both scenarios were stable at the zero risk level i.e. the solution pattern didn't change despite the increase in risk level. This type of stability in the Target MOTAD solution is not unprecedented. McCarney also found that the Target MOTAD model used in his analysis produced solution only at the zero risk level.

CHAPTER 5
SUMMARY, CONCLUSIONS AND LIMITATIONS

SUMMARY

The cotton enterprise has traditionally been an important component of the agricultural production sector of the Louisiana economy. The long-term viability of the cotton enterprise is of critical importance not only to cotton producers, but to the entire agricultural sector of the economy. One important factor in the long-term viability of cotton production is the ability to maintain productivity. Crop rotations have been shown to be beneficial in maintaining or improving crop yields over time. The general objective of this research was to estimate the relative profitability of alternative crop rotational schemes. Economic theories like expected utility theorem, analytical techniques from accounting and economics like budgeting procedures and Target MOTAD model were used to accomplish this task. Specific objectives were (1) Determine costs and returns for selected combinations of rotational patterns and soil type. (2) Determine the economic performance, in a risk-return framework, of selected rotational patterns within a whole farm context.

Crop yield data for the period 1983-93 were obtained from ongoing crop rotation research at the Northeast Research Station. Yield data for the 11 year time period were analyzed for the presence of trend. Liner and curvilinear trends were found in some crop yields. After the removal of such trends, the detrended yield data reflected no change in the means but less variability. Price data for the same time period was obtained from a database available in the department (MILAS). These data were adjusted to a 1993 base.

Given the normally distributed adjusted price data, the means and standard deviations, a set of price data with 44 observations were generated. Input costs were held constant at 1993 price levels to isolate the stochastic changes in yield and price on the revenue side. Enterprise budgets were prepared using the Mississippi State Budget Generator (MSBG), for each of the cropping systems included in the present research. Cotton was considered a program crop and a deficiency payment was included in the income stream when the generated price fell below the target price. These budgets reflected cultural practices and yield levels specific to each production system. Enterprise budgets were also prepared without the deficiency payment to reflect the absence of government programs. The following cropping patterns for commerce silt loam and sharkey clay soils were evaluated:

A. Commerce Silt Loam Soil
    1. Continuous Cotton (CSL1)
    2. Continuous Soybean (CSL2)
    3. Continuous Corn (CSL3)
    4. Cotton-Corn (CSL4)
    5. Corn-Soybean (CSL5)
    6. Cotton-Soybean (CSL6)
    7. Cotton-Corn Soybean (CSL7)

8. Cotton-Cotton-Soybean (CSL8)
9. Cotton-Cotton-Corn (CSL9)

B. Sharkey Clay
   10. Continuous Soybean (SC10)
   11. Continuous Soybean-Wheat Double Crop (SC11)

For cotton and corn production, all input costs except the ginning cost and drying charges respectively (which vary with yield), were held constant. Output price distributions were developed from seasonal average prices received by farmers over the last 11 years. Input costs across the systems vary according to the different input requirements and quantities specific to each system. Therefore, total risk is due to both market and production risks representing variability in price and yield respectively. Net returns from individual crops were aggregated across each rotation to obtain net returns from each rotational pattern. Net returns per rotational acre were determined by multiplying the per acre budgets by the proportion of that crop in the rotation.

A Target MOTAD model was used to maximize the expected income. The solutions are second degree stochastic dominant which is consistent with a risk averse decision maker. Resource constraints used in the model included land constraints and labor constraints. The upper limit for available land was obtained from a representative farm model. The upper limit for available labor hours was obtained from Denison. Coefficients for labor constraints were calculated from estimations of monthly income and expense flows for the enterprise budgets used in the analysis. The risk parameter G was allowed to vary up from 0 to determine further improvement in expected income. Two linear programming models were used for two different scenarios. In the first model all crop rotations schemes were included, and in the second model only continuous crop schemes were included. Two scenarios were examined to determine the impact of government programs. This was done by constructing models with and without deficiency payments in the income streams.

The mean net return from continuous cotton was greater than net returns from all other cropping systems. Both cropping systems on sharkey clay soil, continuous soybean and soybean-wheat double crop, had lower mean net returns than any of the production systems on silt loam soils. However, net returns from continuous cotton had more variability than other net return distributions. Net returns from continuous soybeans on silty soil had a higher mean and less variability than net return from continuous soybean on clay soil. Except for the previous observations, the patterns of means and coefficient of variations did not indicate any superiority of any cropping scheme. Four net return distributions did not follow normal distributions. Without deficiency payments, mean net returns from the schemes containing cotton were found to be less than the mean net returns with deficiency payment.

Results from Target MOTAD analysis suggest that expected incomes are stable at zero risk levels in all scenarios. The decision maker having all schemes in the portfolio with deficiency payment, achieved an expected income of $325,465.02. At this level, only two crop schemes on silt soil, continuous cotton and corn-soybean were included. The expected income dropped to $300,116.08 for the scenario without deficiency payments. At this level for silty soil, continuous cotton dropped from the solution and the cotton-soybean rotation came into the solution. The level of the corn-soybean rotation decreased. For clay soil, the solution pattern of continuous soybean and soybean-wheat double crop were unchanged for both scenarios.

When only continuous systems were allowed in the portfolio, results were found to be inferior to the portfolio containing all rotational systems. With only continuous crops in the portfolio, the decision maker can achieve an expected income of $311,204.42 with cotton and corn in the solution. For clay soil, the level of soybeans decreased and level of wheat-soybean double crop increased from the levels included in the solution of the portfolio containing all schemes. Without deficiency payments, expected income dropped to $279,341.64. At this level cotton acreage decreased and soybeans replaced corn in the solution. The solution pattern of cropping systems on sharkey clay soils remained same as in the portfolio containing all schemes.

Results suggest available silty land could be fully utilized in all scenarios. Clay remained under utilized in all the scenarios with highest under utilization occurred for the portfolio containing only continuous schemes without a deficiency payment. Except full utilization of labor hours in May for clay soil, overall results suggest under utilization of labor hours in certain time periods for both soils.

CONCLUSIONS

The present research evaluated the relative economic profitability of different rotational schemes under production and market risk on two major soil types found in Mississippi delta area of Louisiana. Results show that the continuous cotton system was superior to other rotational schemes on silt loam soil in terms of mean net returns. While mean net returns were higher the enterprise also had the highest variability as measured by the coefficient of variation. Considering whole farm planning with labor and land availability constraints, continuous cotton was the primary enterprise when deficiency payments were included. This result is consistent with the existing planting pattern in Louisiana. However, without deficiency payments farmers would not plant continuous cotton unless only continuous schemes are available.

The Target MOTAD model specified a set of optimal results under different scenarios at zero risk level. The stability of the solution with no risk implies that the representative farm is indifferent to the sensitivity of risk in the decision making process given the information presented in the study with it's limitations. The method did not assume a level of risk or income preference, rather it calculated optimal results for no risk levels. Inclusion of two crop schemes in the solution indicates that environmentally friendly farming practices are not disregarded in the economic decision making process.

LIMITATIONS

One limitation of this analysis is that government programs may be incorporated into a linear programming framework in more constructive manner. The deficiency payment for cotton is simply a price floor with the maximum total payment indirectly incorporated into the model when actually the deficiency payments are based on past base yields that are established, not present yields. The deficiency payment can be directly incorporated only if it is considered as another constraint with the overall limitation of an appropriate dollar amount being the upper limit of enterprises involving cotton. Further, government program provisions incorporated in this study reflect historical programs and may not reflect farm programs of the future.

Another limitation of the present research is that the interdependence between price and yields were not considered. Although the variability in prices and yields were individually considered in reality, farmers make decisions on the basis of an information set where price is a major factor. Such interdependency can be incorporated only if joint distribution models are found to be suitable for practical implementation.

The size of the plots for the crop rotation experiment conducted by Northeast Research station were relatively small. When the yield data from the experiment were extrapolated to a per acre level the problem of potential yield measurement errors might be compounded significantly.

Another limitation of this research was that not all rotational schemes could be included in the analysis. The schemes involving grain sorghum were not included because the yields from the crop were either considerably under estimated or not available due to bird depredation.

While environmental benefits of rotation were alluded to in this study, environmental aspects of the selected cropping patterns were not explicitly included in this analysis. Some benefits of rotations (improved yield, reduced variability in yields, etc. were included in the analysis as reflected in the net returns of the various alternatives.

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VITA

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Major Field: Agricultural Economics

Title of Thesis: Evaluation of Alternative Crop Rotational Schemes for Cotton Production in Louisiana

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